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A STUDY OF URBAN PRINCIPALS' PERCEPTIONS OF TECHNOLOGY  
IMPLEMENTATION AND STEM PROGRAM SUSTAINABILITY

By

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A DISSERTATION

Presented to the Affiliated Faculty of

The College of Graduate and Professional Studies at the University of New England

Submitted in Partial Fulfillment of Requirements

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2018

A STUDY OF URBAN PRINCIPALS' PERCEPTIONS OF TECHNOLOGY  
IMPLEMENTATION AND STEM PROGRAM SUSTAINABILITY

**ABSTRACT**

STEM careers are becoming more prominent in today's workforce. The platform of today's industries derives from science, technology, engineering, and math, the study of which ultimately provides students and stakeholders with the foundation to function in a globally diverse society. Due to the recent budget shortfalls, the existence of STEM programs within this Texas Urban School District was threatened. District principals were directed to review their respective budgets to determine where potential cuts could be made. The purpose of this qualitative phenomenological study was to describe the perceptions of urban district principals regarding technology implementation and identify recommendations for the sustainability of STEM programs within this Texas Urban School District. This research study consisted of six STEM principals, with two of each representing the elementary, middle, and high school levels. The research questions that guide this study are: (1) What are the perceptions of principals regarding the implementation of technology within urban schools? (2) What are the perceptions of principals regarding the sustainability of STEM programs within urban schools? (3) How do urban principals develop knowledge about STEM education? (4) What are the perceptions of principals regarding barriers to learning for STEM students? The results of this study revealed that technology implementation is indeed a vital component in urban education. Collectively, implementation of the technology needed for STEM learning apparently cannot be fully realized if principals lack access due to funding or other circumstances that repress its utilization.

Technology implementation and STEM program sustainability can be increased through programs and businesses that consistently provide STEM resources, higher education contacts, and career pathway opportunities. Continuous professional development and training is needed for STEM instructors, as they educate students as technology evolves and as they strive to support a growing workforce. This study found that STEM learning and teachers' technology implementation are interwoven and work together to build a bridge to prepare students for today's workforce.

Key words: *STEM, Principals, Sustainability, Perceptions, Technology Implementation, Phenomenology, Budget Deficit, Women, Minorities, Funding*

University of New England

Doctor of Education  
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## **CHAPTER ONE**

### **INTRODUCTION**

One of the major educational goals established during the Obama Administration was that students in the United States of America would uphold the highest international ranking comparable to other nations (Modi, Salmond & Schoenberg, 2012). In his address introducing the “Educate to Innovate” campaign, he placed great importance on expanding the STEM pipeline for a robust and innovative workforce (Modi, Salmond & Schoenberg, 2012). He asserted the significance of all students being able to think critically in STEM education. Furthermore, Obama made reference to the critical need for all ethnic backgrounds to be represented in all STEM-related workforce areas. The acronym STEM refers to science, technology, engineering, and mathematics and addresses the growing disconnect between the skills that employers need in a rapidly increasing technological world (Rotherham, 2011). STEM careers in the United States have grown at three times the pace of non-STEM jobs, and are expected to remain at this pace through the next decade (Modi, Salmond & Schoenberg, 2012). During this time, ninety million dollars was allocated to ensure that educators would receive the training required to provide students with the skills and the competitive edge needed globally (Burke, L. M. & McNeill, 2011). STEM campus leaders and supporters assert that cutting edge instruction in science, engineering, mathematics, and the integration of technological resources will help to prepare students towards surpassing other nations as candidates and leaders in the global industry within STEM related fields (Brown, Reardon & Merrill, 2011). Recently, the STEM to STEAM movement has taken root and is surging forward positively to meet the needs of a 21st century economy (Yakman, 2006). In 2015, Georgette Yakman researched the humanities, arts universities, professional organizations, and art groups

to form a more extensive level of analysis of "art" category. Art "A" covers a wide range of humanities and arts subjects, covering social studies, language, physical, musical, fine and performing (Yakman, 2006). The arts were added to address the components that many employers, educators, and parents have voiced as critical elements for students to thrive in the present and rapidly approaching future (Yakman, 2006). Ninety percent of teachers possessed at least one computer in their classrooms by 2010. Seventy-seven percent of the U.S. population age three and over were exposed to the Internet by 2013.

### **The Role of Principals in STEM Programs and Technology Implementation**

Competence in the STEM standards has become a factor in political and economic decision-making. More than ever now in the greater society, the STEM components of science, technology, engineering, and mathematics possess direct links to human health and the goods and services that contribute to personal and social welfare. Adequate funding, strategic planning, and decision making also are major components in technology implementation. To that end, the tenants of STEM and technology implementation are interwoven and work together to build a bridge for all fields in today's industry.

Because technology continues to transform the various operations within today's society, it is pertinent that principals and administrators become adept at using and administering virtual technology. This transformation poses implications for preparing principals with the capacity to critically think, decipher, and implement cutting-edge learning that equips students for increasingly sophisticated personal media and workplaces. Collectively, the technology needed for STEM cannot reach its highest potential if principals lack access due to funding or encounter other barriers that suppress its utilization (Fairlie, 2012; McNierney, 2004; McHale, 2007). The speed of technology implementation is lessened partly because of divided priorities and the

absence of accurate data, resources, and the knowledge of how to make decisions to guide implementation (Roekel, 2008). If evolving technologies were not applied to STEM education, today's current dominant technologies idealized in the past would not exist.

Many implementation challenges should be acknowledged during the shift to STEM education. As a leadership tactic, it is important that STEM initiatives be communicated and that principals listen to stakeholders. Combining expectations with discussions about resources and support increases strong communication at the campus level. Incorporating a new STEM project-based approach into a school's current pedagogical philosophy and improvement plan has to be initially shared and understood by all stakeholders for successful implementation. The focus must be kept on new initiatives for students and a positive academic outcome. To assist with successful implementation, it would be helpful for principals and educators to create professional goals for the visual, reading/writing, auditory, and kinesthetic learners across all subjects. It is also essential that principals and other educators evaluate and reflect on the learning process. Creating goals gives them the opportunity to enhance their own knowledge, reassess assumptions, and ask better questions to improve instruction and student achievement. Professional learning communities allow principals and educators to share and vet projects, while adopting a learning approach to creating authentic experiences for students (Peters, Burton, Kaminsky, Lynch, Behrend, Han, Ross, & House, 2014).

Another leadership strategy that can strengthen principals' background knowledge of STEM initiatives is teaming up with surrounding businesses and stakeholders that embody the components of STEM in today's workforce. Such partnerships provide real world opportunities that allow students to gain preliminary experience and keep principals abreast of the most current trends that can then inform campus curricula plans.

School districts are mandating professional development for principals and other educators to ensure that instruction is aligned to state standards and to respond to the needs of students across all disciplines. Principals should participate in professional development programs respectively designed to help them acquire greater awareness of STEM teaching pedagogy, the individual STEM disciplines, and the mechanics of implementing STEM instruction within a single school (Bybee, 2013). These efforts will provide adequate STEM education for all students, while at the same time generating a professional learning community of principals who can learn from one another as they work to strengthen STEM education in urban schools. Such training offers a model that could be scaled to prepare principals and reach a greater number of students. These types of professional development include both principals and educators. It would need to be accommodated slightly to meet the needs of both administrators and educators, with break-out assemblies to discuss issues of singular concern to each group. Using the strategies by developed experts in the field, would support the implementation process and help to ensure that students benefit from the best practices (Vasquez, Sneider & Comer, 2013).

Principals must be well advised with regards to how technology is implemented in urban schools and how teachers need to adapt their instructional methods to incorporate new devices (Sheninger, 2014). Today's learners are increasingly becoming connected to an engaging multimedia world empowered by technology. To that end, technology implementation has become an integral component of everyday life and has changed the way stakeholders communicate, work, and live. As the recent demand for human resources in science, technology, engineering, and mathematics (STEM), the development of STEM professionals is called

worldwide. The critical need continues in education to equip principals, students, and teachers, with skills and resources to implement quality instruction (Bybee, 2013).

The relationship between technologies offered in urban areas and STEM is technology access and implementation. Online connectivity is continuously shaping the world's economic and social interactions and communication. Internet accessibility by way of wireless access points, mobile networks, or grounded broadband connections is providing individuals the ability to connect online daily. Funding for science, technology, engineering, and mathematics education is one of the most active and growing fields of philanthropy. Great improvements have been made in infusing technology into urban school instruction. School districts have significantly invested in virtual learning environments required to implement STEM programs and evaluate student learning. They have rallied resources to acquire software and technical support for students and staff. Some have even established curriculum standards for STEM technology to ensure that students achieve a certain level of competency before they graduate (Van Roekel, 2008).

Technology implementation and STEM education for the general school population led by principals should be planned and purposeful. STEM is a vital component of today's classroom instruction and influences the learning environment. Technology in the general education population supports curricular goals student learning objectives. The integration of technology at urban high school campuses encourages higher order thinking skills. Technology is used to encourage collaboration in and out of the classroom, as well as facilitate projects that would be difficult or impossible. Technology supports the construction of knowledge in general education and is essential to the learning activity (Davis, 2010).



Additional skills are required for applying knowledge of those subjects in the real world. Principals and teachers must be made aware of funding and resources so that STEM programs can operate. The hiring process performed by principals for staff at STEM schools can include assessing prospective teachers' comfort levels with the adoption of STEM curriculum and collaborative skills. STEM schools leadership should strive to have similar hiring filters in place, while principals approach education through training, technology implementation and then onward towards STEM curriculum integration. Awareness is critical for STEM education implementation. For STEM schools to be successful, principals must be mindful of equipment, materials, upkeep, repair, and additional expenses that add to the overall campus budget. Accommodations should also be made for students lacking information and communication technology access outside of school. These are critical strategies to avoid potential barriers and enhance innovation with STEM. Through partnerships with businesses and universities, grants or donations may be able to cover some of the costs of providing resources for students. For schools to know what technology services are needed and by whom, some type of assessment should be conducted (Sersion, Schools & Stevens, 2012).

Technology implementation for students in STEM education typically is successful when teachers use problem-, project-, or design-based assignments to engage students in addressing complex contexts that reflect real-world situations. Current research in project-based learning illustrates that projects can increase student interest in science, technology, engineering, and math (STEM) because they connect students in solving actual problems, working with others, and producing real world solutions (Fortus, Krajcikb, Dersheimerb, Marx, & Mamlok-Naamand, 2005). Technology implementation in STEM means operating within the context of tasks that compel students to use knowledge and skills from multiple disciplines.

District leadership plays a vital role in implementing technology effectively into the classroom as is considered a complex school-wide change (Schrum, Galizio, & Ledesma, 2011). Effective technology implementation requires a cultural shift away from traditional instructional practices and towards technology-based practices designed to improve learning. To facilitate this change initiative, several districts are exploring opportunities for stakeholders and students that include collaborative learning opportunities, online repositories of tutorials and lesson plans, and coaching. Principals serve as the key catalyst in the implementation of technology used for instruction in school settings (National Center for Education Statistics, 2010). The International Society for Technology in Education's (ISTE) National Educational Administrators Standards supports this research towards exploring the themes that surround: digital-age learning culture, visionary leadership, and excellence in professional practice (ISTE, 2015). Technology implementation has been shown to help create more authentic learning environments where students are encouraged to attend, have a greater chance of communication, and have more opportunities to use higher order problem-solving skills that are connected to real world applications. The decision makers in public schools establish the climate for technology integration into the educational system (Holt, C., & Burkman, 2013). While decisions about staff training, learning platforms, and networks remain a very local matter, a set of well-recognized challenges face school leaders (Holt, C., & Burkman, 2013). These include integration of technology into the classroom to improve instruction, the availability of funding for technology, and accessibility for all students regardless of personal means (Holt & Burkman, 2013).

### **Urban School District Challenges**

The platform of many of today's industries derives from science, technology, engineering, and math. Study of those fields ultimately provides students and stakeholders with

the foundation towards functioning in a globally diverse society (Yakman, 2006). STEM curriculum is an interdisciplinary means of providing students with advanced project-based learning opportunities and real-world experiences. This was initially introduced during the latter portion of the twentieth century and quickly became an educational emphasis that ignited support from the United States Government (Thomas & Williams, 2010). Each year, urban schools receive a percentage of supplemental funding from the United States Government. The extra funding within this Texas Urban School District allows principals to hire educators that are specifically trained in STEM subjects within schools. It also provides students the opportunity to participate in hands-on learning with labs, virtually enhanced curricula, and field trips.

District school boards review annual budgets to account for all expenditures that define the operations of the organization. For over a decade, this Urban School District has supported its magnet, gifted and talented, fine arts, and STEM education based upon the funding allotted from the state and government. During the 2016-17 school years, the district, unfortunately, faced a significant budget shortfall of 107 million dollars. Chapter 41 of the Texas Education Code, the state school funding system expects districts designated as property-wealthy to direct tax dollars back to the state (Texas Education Agency, Ch. 41, 2016). This process is known as “recapture” and is commonly referred to as “Robin Hood” (Texas Education Agency, Ch. 41, 2016). The money is then redistributed to districts deemed to be property-poor, as well as to the state’s general fund for use for non-education purposes.

### **Statement of Problem**

Due to the recent budget shortfalls within the last few years, the existence of STEM programs within this Texas Urban School District has been threatened. District personnel and principals were directed to review their respective budgets to determine where potential cuts

could be allocated. Many of these cuts ultimately affected the reduction of school curriculum electives and the STEM programs with a reduction in resources and staff members qualified to teach in STEM-specific areas. How do principals sustain these STEM programs despite the challenges that they face? This study examined the factors that principals perceive as challenging STEM program sustainability at urban campuses (Texas Education Agency, Ch. 41, 2016). The principals' perceptions regarding the impact of budget cuts is a central factor in identifying sustainability strategies.

### **Purpose of the Study**

The purpose of this qualitative study is to describe the perceptions of urban district principals regarding technology implementation and identify recommendations for the sustainability of STEM programs within this Texas Urban School District. Leaders must establish a clear vision while executing a process that includes technological savviness, global awareness, communication, stakeholder engagement, and innovation. With regards to urban district stakeholders, various professionals are influential in ensuring the improvement and constant development of all stakeholders. The findings of this study address the select campus principals' perceptions and emerging themes they perceived as influencing STEM program sustainability.

As reported in a publication by the National Research Council (2011), STEM education occurs in some capacity in most United States schools; however, the level of effectiveness with implementation varies significantly (Howard, 2014). Although supportive of program goals and with positive intentions, many educators and their institutions have failed to fully implement the approaches needed to produce educated, highly prepared students that potential employers are seeking (Hughes, 2009).

Because the technology demands of the twenty-first century are constantly evolving, the federal and state mandates suggest that principals must adjust their existing curricula to include the latest digital leadership practices (Sheninger, 2014). Such a commitment ultimately supports the validity of STEM Programs and technological implementation practices in education.

As a technology implementation and STEM sustainability strategy in challenging urban areas, securing business partnerships and STEM outreach programs has provided school districts the access to curated content, collegial learning, and personalization based on district goals and data implications for future growth (Bybee, 2013). These programs engage with local schools, administrators, educators, after-school programs, students, and families to enhance the understanding and appreciation of science, technology, engineering and math subjects. This includes making STEM education accessible to underperforming and underrepresented groups (Bybee, 2013).

In 2016, Massachusetts Institute of Technology announced a new initiative known as the PK-12 Action Group. This initiative aims to bring MIT's unique "Mind and Hand" learning approach beyond the campus to pre-kindergarten through grade twelve learners and teachers around the world, building upon existing efforts and developing new ones (Bybee, 2013). The action groups recognize a growing necessity in STEM education by starting new research, design, and outreach programs that will transform how students learn and the understanding of how students learn. This means consistent designing of targeted solutions that range from low-cost laboratory instruments to innovative computing environments (Bybee, 2013). The result of this advancement renders the understanding of teaching and learning through a various set of research methodologies, from basic cognitive science and neuroscience to design-based research and classroom experiments (Bybee, 2013).

The Rice Office of STEM Engagement (R-STEM) supports and promotes Rice University's wide-ranging efforts to progress K-12 science, technology, engineering and mathematics (STEM) education in regional school districts (Rice, 2017). It serves as the central point of contact for school districts, administrators, parents, students, nonprofit organizations, faculty, and others in the region, regarding various STEM programs. The Dream Achievement through Mentorship strives to increase the number of underrepresented minority students and women with interest in pursuing undergraduate degrees in STEM fields (Rice, 2017). Rice University students studying in STEM-related fields and principals that are alumni serve as mentors for small teams of high school students. Providing access to interactive classes, global networking, and infusing STEM expert-led online training has allowed districts to utilize virtual platforms to transform instructional practice and reinforce the professional growth of their stakeholders.

### **Research Questions**

The research questions that guide this study ask:

1. What are the perceptions of principals regarding the implementation of technology within urban schools?
2. What are the perceptions of principals regarding the sustainability of STEM programs within urban schools?
3. How do urban principals develop knowledge about STEM education?
4. What are the perceptions of principals regarding barriers to learning for STEM students?

## **Conceptual Framework**

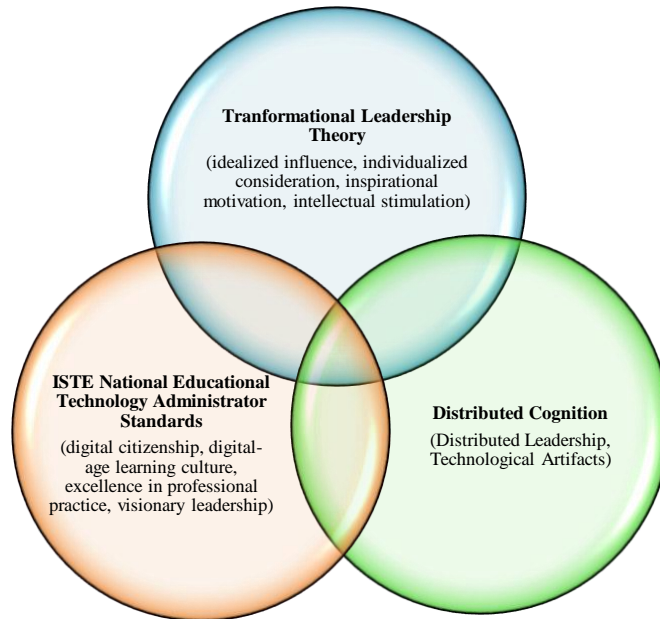
The conceptual framework for this study conveys the interrelationship of the distributed cognition theory, the ISTE National Educational Technology Standards for Administrators, and the transformational leadership theory. The transformational leadership theory provides the concepts of idealized influence, individualized consideration, inspirational motivation, intellectual stimulation. These tenets will ultimately surface as the campus administrators describe their experiences regarding urban district technology implementation and STEM Program sustainability.

The ISTE National Educational Technology Standards renders digital citizenship, digital-age learning culture, excellence in professional practice, and visionary leadership. Each of these elements is deemed a vital component of successful administrative practices and is supported by Texas Education Agency. As the principals describe their challenges, these concepts were explored regarding how technology is implemented and how STEM Programs might be continuously strengthened and sustained.

Distributed cognition and distributed leadership suggests that virtual resources can be studied as technological artifacts to promote learning within an organizational setting. This theory requires the sharing of cognitive activity among the parts and participants of this system, which can be other individuals or artifacts such as, technologies or media (Bell & Winn, 2000). The participants distribute their cognition among other learners and physical or digital artifacts by externally displaying their knowledge (Bell & Winn, 2000). The role of technology within the distributed cognition theory is that of a valuable component within an urban school system, in which the stakeholders are interacting. This interaction can either help to distribute their

knowledge, off-load certain amounts of cognitive work making the cognitive load less, and contribute to scaffolding new capabilities (Bell & Winn, 2000).

All three of these units provide the platform to investigate the principal perceptions of technology implementation and how STEM Programs are sustained. Figure 1.1 below provides a model of these three concepts combined to serve as the foundational framework of this study.



*Figure 1.1: Conceptual Framework. This figure depicts the elements that complete the framework of this study.*

### **Assumptions, Limitations, and Scope**

Today's millennials are placing heavy demands on educational stakeholders to create learning environments that are flexible, easily accessible, measurable, and immediately transferable to real-world employment situations (Sheninger, 2014). Stakeholders are recognizing that incorporating a myriad of technological tools, mobile devices, and web-based instruction has created a new, quickly-evolving era of educational opportunities for learners.

The transformational leadership and distributive cognition theories support a variety of strategies that can stimulate an organization's change processes. This is especially essential for the various technological tools that are utilized by urban school district stakeholders. Several



campus leaders consistently implement these resources through the applications of learning management systems (LMS), Web 2.0 Tools, and various drivers of social media. Distribution cognition also reveals restrictions that are implied by the embodied nature of the representational media that are inevitably employed in carrying out a given task (Bell & Winn, 2000). This is mostly reminiscent of larger organizations that utilize technology on a greater scale, such as Texas Urban School District. Bennis and Nanus (2007) stated that, “the larger the organization, the greater their complexity of interaction, and the quicker their shift in emphasis over time” (p. 87).

Another limitation to consider is stakeholders who are unwilling to change or accept the evolution of technology. Mainstream society is now more heavily invested in utilizing technologies for both personal and professional reasons. The continuum of this type of development poses implications for today’s urban educational organizations, as they strive to remain relevant for the students of the twenty-first century. Now is the time to transform educational institutions into rigorous and vibrant learning communities that are digitally connected and extend access to practical tools that help stakeholders unleash creativity and innovation (Sheninger, 2014).

### **Significance**

Providing urban schools with the accessibility to technological resources and ISTE aligned STEM curricula ultimately helps to support the development of stakeholders in becoming producers and evaluators of knowledge. Most importantly, students develop the skills they need to compete in today’s technologically demanding economy. As technology evolves, campus administrators must understand that implementing technology and incorporating STEM Programs into school curricula helps to enhance innovation, rigor, critical thinking, and real-

world preparation. The implementation of technology can engage, connect, empower, and enhance stakeholder relations (Sheninger, 2014). This vision of leadership begins with identifying obstacles to change, and specific solutions to overcome them to transform today's schools (Sheninger, 2014).

### **Definition of Terms**

For the purposes of this study, the following definitions were used:

*Accessibility:* The capability of engaging into a virtual platform through the utilization of a digital resource (Geer & Sweeney, 2012).

*Blended Learning:* An educational program where a user is provided the opportunity to experience learning through a face-to-face and virtual platform (Sheninger, 2014).

*Categories:* Conceptual elements that cover or span many individual examples or units of the data previously identified (Creswell 2013, p. 181).

*Commerce:* The electronic buying and selling of goods (Winn, 2012).

*Digital Citizenship:* The standards of behavior regarding technology usage (Ribble & Miller, 2013).

*Distributed Leadership:* An emerging set of ideas that frequently diverge from one another (Spillane, 2015).

*Etiquette:* The criteria of conduct or procedure of a particular setting and environment.

*Learning Management System (LMS):* A software application that provided the virtual platform for data tracking, documentation, collaboration reporting, training, and professional development (Sheninger, 2014).

*Professional Learning Community:* A continuing process in which educators work collaboratively in recurring cycles of shared examination and action research to achieve

improved results for the students they serve (Sparapani, Pietras, Rogers, Voydanoff, MacKay & Fuchs, 2016).

*Stakeholder:* A person or entity that has vested interest in an organization (Fulton, 2012).

*Sustainability:* Maintain full operation of any K-12 school program over multiple years with adequate funding and staffing resources to deliver the overall intent of the specialized program.

*Technology:* Refers to personal computers, networking devices and other computing devices (e.g., electronic whiteboards and personal digital assistants (PDAs); also includes software, digital media, and communications tools such as the Internet, e-mail, CD-ROMs, and video conferencing (Principals Technology Leadership Assessment, n.d).

*Technology planning:* Any process by which multiple stakeholder groups (e.g., district administration, school administration, faculty, and parents) convene to develop a strategy for the use or expanded use of technology in instruction and operations. Technology planning need not be separate from other planning efforts but should be a recurring theme if integrated within a more comprehensive planning process (Principals Technology Leadership Assessment, n.d).

*Web 2.0 Tools:* the transition from basic Internet usage to second generation dynamics and web applications.

### **Summary**

Technology implementation and STEM programs provide channels for district principals to ensure learning opportunities for all stakeholders. This alone challenges principals to provide students with the accessibility to more STEM funded opportunities. As funds are lessened or become constrained, the opportunities for students are may be threatened. Principals must prepare with effective strategies to address the demands that are becoming evident in society (Sheninger, 2014). It is safe to predict that innovative, non-traditional technological leadership

modalities will continue to grow over the next decade, in both quantity and quality (Sheninger, 2014). Within urban school districts, technology has contributed: social networking, personal learning networks, learning management systems, professional learning communities, and various other components that continually make learning possible at any time. Web-based instruction has rapidly gained popularity with younger tech-savvy learners, thus providing the flexibility demanded by stakeholders in K-12 and higher education institutions alike. The scope of this analysis speaks to the evolution of traditional instructor-led environments towards e-learning implementation. This chapter provides an introductory look into the impetus that surrounds the technology implementation and how budget cuts have threatened STEM education plans within this Texas Urban School District. As a result of the budget constraints, several campuses and district offices experienced a reduction in force of staff and partnerships that rendered STEM support resources. Chapter 2 will explore the literature that defines the history, expectations of principals, and vision regarding technology implementation and intent of STEM programs.

## **CHAPTER TWO**

### **REVIEW OF LITERATURE**

The review of literature for this study is apportioned into four sections. First: the review examines the historical nature of STEM and the impact of technology within political, economic and social platforms. Second, it will explore the perceptions of principals and curriculum development aligned to the International Society for Technology in Education's (ISTE) National Educational Administrators' Standards the Texas Education Agency (TEA), and technology implementation through the technology, pedagogy, and content knowledge framework (TPACK). Third, the transformational leadership factors are reviewed to understand how campus administrators enact program implementation as agents of change inside the urban STEM school environment. Finally, this review will explore the leadership and vision for technology in urban and STEM education, as the evolution of virtual practices has become inevitable in society. The review of the literature provides the premise for further investigation of technological implementation models and describes implications for school leadership and STEM program continuity.

#### **STEM: A Historical Virtual Paradigm**

The Soviet Union's launch of Sputnik in 1957 heightened the awareness of the need for science and technology education in the United States (Thomas & Williams, 2010). According to Confrey, House, and Bhanot (2008), it was competition heightened by the Cold War and the race to early space exploration that brought about the emergence of a focus on mathematics and science in the late 1950s and early 1960s. These politically motivated forces spurred the United States to embrace STEM education aggressively. This reactive response according to Thomas and Williams (2010) is consistent with history. STEM education has always moved to the

forefront in step with historical events that potentially threaten our national defense or our international economic position. An immediate response to one such threat was the passing of the National Defense Education Act (1958), a bill created to fund education improvements in mathematics and science (Drew, 2011). “New math”, for example, emerged as one of the reforms from the NDEA and the National Science Foundation (NSF) in an attempt to transform the teaching of mathematics. The NDEA funded several reforms, as the search for new approaches to instruction was undertaken (Drew, 2011). This mid-twentieth century event that challenged America’s global position with technology is an early example of the influence politics has had on educational decisions in history.

The STEM movement was beginning to gain attention during the 1960’s and 1970’s as evidenced from the momentum gained over the decades based on the economic and social issues of the time. It was in the early 1990s that the National Science Foundation (NSF) began referring to programs that incorporated the academic content areas of science, mathematics, engineering, and technology as: ‘SMET.’ The acronym lacked appeal and quickly changed to STEM (Science, Technology, Engineering & Mathematics) as reported by Sanders (2009). According to Bybee (2010), the term has been used as a label for any event, policy, program, or practice that involves one or several of the STEM disciplines (p. 30).

When STEM was initially introduced as a concept, according to Bybee (2010), it gained the attention of many groups concerned about the ‘eroding’ academic performance of United States students. The concerns were legitimate. Based on 2007 measures from Trends in International Mathematics and Science Study (TIMSS), though the United States was once a leader in STEM, it lost that status some time ago (Alvarez, Edwards & Harris, 2010); as of 2011 the U.S. ranked 22<sup>nd</sup> in science, and 31<sup>st</sup> in math among peers in comparative countries around

the world (Burke & McNeill, 2011). The STEM phenomenon is not a new initiative (Thomas & Williams, 2010). The authors stated that it had been a century since schools first identified concerns about the political, economic and social topics associated with STEM education.

In the State of Texas, STEM education in schools has become more evident. Many of its districts have recognized the urgency to address the growing STEM education and industry needs across the state. Different states will of course need distinct education and workforce strategies for filling the pipeline of STEM talent in areas of greatest need (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Students who gain a strong STEM foundation today will face brighter prospects in years to come (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Their skills will be resilient even as markets and technologies change. States that focus on the STEM learning of their youth are investing in a prosperous future where they can attract innovative new industries (Langdon, McKittrick, Beede, Khan, & Doms, 2011).

### **Urban Campus Technology Leadership through the Eyes of ISTE**

As the continuum of technology leadership evolves within education, there is a need for campus administrators to equip their students with access to the latest virtual technology and strategies. Effective preparation of teachers makes it feasible for them to connect with today's learners, as they are utilizing technology as their most major method of communication, instruction, information gathering, and learning. This is because most students have been immersed in technology as adolescents. To prepare campus administrators for technological implementation in urban schools, the International Society Technology Education (ISTE) developed the NETS-A Standards for Administrators to support school leaders with guidelines for technology training and preparation strategies to implement at the campus level and throughout the district. Don Knezek, former president of the International Society for

Technology Education (ISTE), concurred that since school administrators play a prominent role in the implementation of school reform, their perceptions concerning technology implementation are most relevant (ISTE, 2015). ISTE maintains a membership of over one hundred thousand educators and a publication called *The Journal of Research on Technology in Education (JRTE)*, which offers an extensive array of professional development, conferences, and online resources (ISTE, 2015). These five standards in Figure 2.1 promote an approach by school leaders that is comprehensive in its provisions for an atmosphere favorable to learning using digital modalities. These standards provide the lens that will be used to examine the factors that drive successful technology implementation in a Texas Urban School District.

The International Society for Technology in Education's (ISTE) National Educational Administrators Standards supports this research exploring the themes that surround: digital-age learning culture, visionary leadership, and excellence in professional practice. The leitmotif of these areas provides an extensive look at the successes and challenges that campus administrators identify. Figure 2.1 below displays a model of the components that formulate the administrator strands.



**Figure 2.1: ISTE Standards for Administrators.** This figure depicts the virtual components that guide administrators through embedding technology at campuses and workplaces (ISTE, 2015).



## **Digital Age Learning Culture**

A digital-age learning culture is one that is focused on collaboration and communication. From a STEM perspective, the digital leader is called to create, encourage and sustain a culture where stakeholders discuss, observe, critique, and plan together (Bybee, 2013). The creation of this collaborative culture is the most important action the school leader can take to ensure successful integration of technology for enhanced learning. Campus leaders strive to make sure that learners gain a relevant knowledge by promoting instructional innovation, modeling effective use of technology, and monitoring how technologies and related practice are infused into the curriculum. Innovative stakeholders have an opportunity to blend face-to-face and digital learning models to advance learning in the twenty-first century.

Digital age learning calls for a new form of responsibility for school leaders. Skills shortages in STEM (Science, Technology, Engineering, and Math) education have been identified as threats to learning development around the world, and have been reported in United States, Europe, and Australia (AIG, 2013). Many school districts possess a core technology plan to guide leaders to move forward from being unprepared or unqualified to identifying and integrating technology into instructional practices. To take part in digital age learning, stakeholders must explore, evaluate, and apply technology as it correlates with differentiated instruction. Technology offers some convenience with being always readily available. Digital age learning that includes a STEM curriculum helps to build the relationship between teacher and learner. It engages students in higher-order thinking skills and supports the creation of content and critical thinking. Students are introduced to a culture of collaborative learning strategies (AIG, 2013).

## **Visionary Virtual Leadership**

District leaders must articulate a shared vision of how technology will be effectively used to support teaching, learning, and school management (Sheninger, 2014). Many stakeholders are affected by the incorporation of technology in schools; therefore, it is imperative that all audiences be recognized and involved in the process. Generating and communicating a vision suggests an understanding of how educational technology affects each audience and why it is relevant to each audience. When the vision is conveyed in ways that are meaningful, stakeholders are more likely to share in the vision. There must be consensus that every stakeholder has a voice and the assumption that all are willing to embrace the technological changes of today. A vision begins with dialog but will only become a reality with action (Sheninger, 2014).

It is recommended that school districts articulate a shared vision that incorporates technology into the arena of curriculum and instruction. School leaders must take proprietorship in a vision to ensure that campus technology programs are cutting-edge and moving forward. Technology has become more accessible everywhere and is becoming more user-friendly (International Center for Leadership in Education & Sheninger, 2014). However, it is unquestionably critical that education leaders stay abreast of the technological trends in the upcoming years. Stakeholders may accept that technology can be used in various ways but might not possess the knowledge of the larger educational infrastructure and implications for implementation. However, the larger the school district, the more multidimensional the technology plan becomes, as leaders distinguish between existing assets and needs while providing the support to staff. As there is often a just-in-time need for resources, campus administrators must provide continuous support to their teachers. Educational staff can

experience growth more efficiently if a district has embraced a proactive technology plan preliminarily (Fulton, 2012).

The lack of a vision for technology renders the outcome of mediocrity. The final challenge is school leaders being unaware of virtual advancements and sustaining programs that are not relevant. There is a continued momentum in technology, which requires all leaders to remain visionary and respond accordingly. Not being adept with the latest technology and the awareness of its progression will leave inadequacies within the urban school district (Sheninger, 2014).

Educators are providing more virtually enhanced programming with the explosion of online learning formats. This format of teaching is nontraditional and responds to the expectations of many stakeholders. Once reserved for colleges and universities, public school districts now implement virtual modalities for learning, training, collaboration, and data capturing. Texas employs The Texas Virtual School Network (TxVSN). The network gives students access to online courses and instructors. The classes are taught by state-certified instructors trained to deliver quality online instruction (Texas Education Agency, 2016). As online courses have commenced, there is a greater need for virtual textbooks, tablets, and smartphones. These needs challenge educational leaders to become more innovative with and knowledgeable about instructional strategies that align the interwoven concepts of technology and STEM. Constant checkpoints are required to ensure that technology plans are meeting organizational needs within and beyond the classroom.

### **Digital Citizenship**

Often overlooked is the proper use of technology within school districts. Stakeholders are required to sign and support satisfactory use policies. It is the obligation and commitment of the

school district to ensure that all parties concerned understand the social, ethical, and legal concerns and liabilities as parallel to virtual environments (Ribble, Bailey, & Ross, 2014). All educational leaders have to facilitate the open discussion with their students and staff about appropriate technology use. From that point, campus administrators can present information to their staff, so all involved can be more knowledgeable and work together to identify and understand the proper and competent use of digital resources in education.

Digital citizenship is established within the standards of behavior regarding technology usage. As a means of learning the complexities of digital citizenship and the issues of technology use, abuse, and misuse, there are nine common domains of behavior that make up digital citizenship (Ribble & Miller, 2013). The nine standard fields are etiquette, communication, education, access, commerce, responsibility, rights, safety, and security.

Etiquette is the criteria of conduct or procedure of a particular setting and environment. Attention to etiquette for online behavior makes everyone a role model for students. The obstacle with teaching digital technology is not all the rules have been written about uses for these devices. Communication is the electronic exchange of information. Communication requires use of cell phones, instant messages (IM), and e-mail. These routes of communication have revolutionized the means with which technology users interact. These forms of communication have generated a new social formation of whom, how, and when people associate. Education is the manner of teaching about and acquiring technology and the application of technology (Geer & Sweeney, 2012). It is becoming technology inspired and more ordinary every year.

Technology availability in the classroom is becoming as common as the whiteboard and pencil. Teaching students to use technology, however, has not developed and improved equally. Digital inspired teaching does not regularly incorporate teaching about proper and improper practices of

technology resource use (Geer & Sweeney, 2012). Access requires recognition of the responsibilities of electronic participation in the virtual community (Geer & Sweeney, 2012). Full access is beneficial to technology development since it provides more opportunities for scores of people to access and use alternative methods of communication. Some stakeholders might face the challenge of usage or accessibility to virtual tools in the new digital society. Often these options are only accessible to a small group of stakeholders, even though the price of technology is varied.

Commerce refers to the electronic buying and selling of goods (Winn, 2012). Online shopping is quickly becoming the standard way of purchasing many products, and students need to understand this method. The object of retailers is to inform citizens of the latest and greatest merchandise available. Discussing digital commerce is critical. There is reliability for electronic responsibility for behaviors and actions. Students have learned about it at an early age and have discovered it simple to find and download material from the Internet. Unfortunately, distinguishing right from wrong, legal or illegal, is a challenge for many (The Recording Industry Association of America (RIAA), 2016). When generating or distributing something digitally, students must understand the related copyright protection as any other content authors. Safety is the physical welfare in the digital technology world. Students must be cognizant of the physical risks and threats that are natural in using technology. Sensitive information is stored electronically. Web sites use data protection software to protect personal and confidential information. Students have to learn about the use of virus protection, firewalls, and off-site storage to protect electronic data. Digital security goes beyond guarding equipment. It includes protecting one's identity from outside influences that would cause financial and social harm (Winn, 2012).

## **Systematic Improvement**

Campus leaders at all levels must consider the various perspectives on technology and prepare for the implications. First, educational leaders have to look at their schools and identify the challenges with their technology. Inadequate technologies must be evident in the shared vision. The technology plan should indicate the current status of the resources. If integrating technology is a priority, a long-term goal should be evident. There should be an evaluation of how students and teachers are using technology in classrooms. To proceed with any instruction, there should be evidence that resources are implemented correctly. The evidence will support the assurance of instruction and learning. Policies and procedures within the technology plan should align with the school district's digital leadership vision. Not all school districts are the same. Some possess leading technology professionals in management who maintain and develop both the tools and the curriculum. Administrators, teachers, students, and instructional technology staff must work harmoniously to communicate the evolving technology needs and perspectives. To resume advancing the educational system through the dynamic and inventive use of technology resources, leaders must implement digital age leadership (Lagemann, 2015).

Technology in education is directed for the benefit of the tools and applications used. The technology must be adequate in the acquisition of knowledge. The interaction between users and resources must render tangible effects for using technology. Software programs used in the classrooms must possess the potential to influence student's learning experience significantly. Educational software should render the pedagogy of the program valuable and relevant. Relevant pedagogy is required to engage and involve children in learning with the easiness of use, satisfaction, and interactivity between the child and programs. Also, the software program tracks data and monitors the progress of the student's learning (Stošić, 2015).

## **Excellence in Digital Enhanced Professional Practice**

Urban campus leaders endorse an environment of professional education and innovation that empowers educators to broaden student learning through the infusion of modern-day technologies and virtual resources. This transformational leadership approach encourages collaboration and communication among members of respective professional learning communities and fosters the formation of a digital-age learning culture. As a technology leader, one must be active in ensuring that instruction is innovative while still meeting curriculum outcomes and student learning gains (Sheninger, 2014).

Professional learning is now presented in face-to-face settings and on virtual platforms. Learning virtually has become more modern and accessible. Professional development opportunities in technology also permit stakeholders to earn trust and change more into technology refinement (Kopcha, 2012). The approach is to create a technology task force to assist in coaching and training. Training programs can be purchased to assist as well. Training must be continuous and provide support. Some suggestion includes starting stakeholders at one skill level. They can progress through succeeding steps in a ranking arrangement. The user will obtain information with technology while recording their growth and learning. Alternatively, stakeholders should have the option to test out. Stakeholders with advanced skills can move past their current skill set. It is motivating to some to receive incentives for completing training cycles.

Course management systems like Moodle, Blackboard, or Canvas can provide the platform to share classes or information with stakeholders. Campus administrators will be more inclined to complete training after school or remotely. Teachers can work with the technology in their classrooms for practice. Digital leaders should inspire teachers to collaborate after training

and attend technology conferences. Also, it would be beneficial for the moderator to create a team of trainers for those that need additional support. To safeguard the success of a technology plan, facilitators have to be creative and use the best methods to promote collaboration, learning, and technology usage (Buabeng-Andoh, 2012).

### **Technology Leadership, Productivity, & Practice in Texas**

Around the world, the tremendous need for and growth in technology have shaped every sector of business, government, society, and life. These significant changes are pertinent to creating earning success for future generations. Advances in science, technology, engineering and mathematics (STEM education) around the world have put in motion a new generation of intellectual and economic expectations. Advanced technologies are affordable and accessible, and therefore, more inclusive. Whereas, in the past, diverse individuals and small groups of marginalized people were not considered a competitive force in the economic structure of society. At the same time, large corporate organizations of the twentieth century are facing challenges with old infrastructure. Human resources departments are toiling to attain the intellectual talent and skill set essential for growth in an economy that flourishes because of intellectual labor (Scott, 2012).

Texas has an ambitious digital learning plan when compared on a national scale to other states. It ranks eleventh in the United States in a report conducted by Digital Learning Now (Alexander & Golsan, 2014). In a three-part phase, the Texas Education Agency (TEA) has a plan in place to meet educational demands. By the year 2020, all Texas schools will have successfully implemented The Long-Range Plan for Technology, 2006-2020, of the Texas Education Agency for full integration of technology in schools. The plan tracks the status of educational technology, and the goal is to prepare students to operate in the twenty-first century



(Texas Education Agency, 2014). According to the plan, Texas students will become rigorous learners, and they will use technological resources and social networking technologies to work together, construct knowledge, and provide solutions to real-world challenges. Students will have the ability to use their personal, Internet-ready devices for learning in the classrooms. Global and cultural awareness are essential tenets for this computer age. Students will also use digital media to communicate effectively in a variety of formats for diverse audiences. These requirements align with the STEM program movement that President Obama deemed as essential to preparing students for today's industry (Modi, Salmond & Schoenberg, 2012).

**Assessment & Evaluation.** For academic growth measures, the plan will allow students to use research-based strategies and critical thinking in all subject areas to boost academic achievement. Digital portfolios are great for creativity and are innovative in maintaining academic growth. It is more convenient for teachers to stay current with trends and policies. New and accessible technologies create the freedom and convenience to incorporate teaching strategies into daily instruction and learning. This technology plan provides opportunity for all stakeholders. Each content area must include student expectations to incorporate the use of technology. These standards are called the Texas Essential Knowledge and Skills (TEKS) for Technology Applications (Texas Education Agency, 2016).

The Technology Applications Educator Standards are used to gauge progress of students' mastering technology skills. The tasks of teachers and librarians are an added value to students' learning experiences. Instructors are expected to develop innovative programs or activities to create a learner-centered environment aimed at enhancing student's learning outcomes, which suggests that there must be an understanding of technology resources available. These resources

can promote instructor-student interactions along with peer interaction that will assist to secure a technological alliance and the fulfillment of students' needs (Revere & Kovach, 2011).

**Social, Legal, & Ethical Issues.** Theoretically, within all professions, individuals must understand the expectations that propel all dimensions of their work. This is especially important regarding STEM program curricula and career objectives. Ethically teachers must also adhere to specific codes and laws that require compliance measures within their instructional practice. Technology provides the gateway of communication and interaction for all professions (Sheninger, 2014). Along with the premise that education needs virtual leadership, Shapiro and Stefkovich (2013) attested that practitioners must inquire about the expectations of community stakeholders, and about what should be taken into account, regarding the best interest of students and their needs (p. 36).

Standard 5 of the National Policy Board for Educational Administration states that “a leader of education promotes the success of students by acting with integrity, fairness, and in an ethical manner” (National Policy Board for Educational Administration, 2015). This standard aligns with the ethics of the profession theory. On the contrary, it should not be forgotten that professional codes of ethics serve as guideposts and aspirations for a field, offering statements about its appearance and character.

Technology acts as the lifeline to most professions that are depended on with regards to ensuring that societal operations are implemented successfully. As a catalyst, the ethics of the profession is asserted within the presence of educational leadership and is deemed essential (Noddings, 1992). The focus on the best interests of the student is reflected in most educational, professional association codes and is a basis of care ethics. Studies have shown that students become more successful when they are aware that the educators are supportive

of them as an individual and their needs (Sheninger, 2013). Shapiro and Stefkovich (2013) asserted that educational leaders or students in training develop their professional and personal codes through focusing on specific paradigms or, optimally, integrating the ethics of the profession, the ethics of care, and various other theories (p. 30). This filtering process provides the basis for professional judgments and organizational decision-making reminiscent of budget funding, grant support, and sustainability strategies.

### **Technological Pedagogical Content Knowledge Model (TPACK)**

Effective STEM practice requires strategic technology implementation (Mishra et al., 2016). Infusing technology into academia requires skills and creativity supported by education professionals' technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006). To promote competencies for STEM education professionals, the technological pedagogical content knowledge model contains the essential qualities of knowledge for highly qualified education professionals (Srisawasdi, 2012). The three components of teaching are content, pedagogy, and technology. These elements collectively produce the heart of the technology, pedagogy, and content knowledge (TPACK) model. The TPACK framework is a model that helps education professionals to consider how their knowledge domains intersect to teach and engage students with technology effectively (Koehler & Mishra, 2009).

### **TPACK Forms of Pedagogical Content Knowledge**

The TPACK framework is based on Lee Shulman's explanations of pedagogical content knowledge (PCK) and illustrates how education professionals comprehend technologies. Such a framework provides guidelines for effective teaching with technology. Its three primary forms of knowledge are content knowledge (CK), pedagogy knowledge (PK), and technology knowledge

(TK). Content knowledge represents education professionals' expertise about the topic to be studied (Koehler, 2012). This type of knowledge includes comprehension of concepts, theories, ideas, organizational frameworks, evidence and proof, and developing practices and approaches. Pedagogy knowledge involves cognitive, social, and developmental theories of learning and the application to students in the classroom. Campus administrators must understand how students construct knowledge, acquire skills and develop habits of mind and positive dispositions toward learning (Koehler & Mishra, 2009). Technology knowledge is everchanging and constantly evolving and is necessary to master various tasks using information technology and to develop different ways of completing a given task. This form of knowledge is applied in real world instances in education and workforce development, which align to the concept of STEM. Technical knowledge is the understanding of informatics as being a help or hindrance (Koehler & Mishra, 2009). The interaction between all three forms of knowledge ultimately creates the technology, pedagogy, and content knowledge framework (Koehler, 2012).

### **Contexts of TPACK**

Pedagogical Content Knowledge (PCK) supports an education professional's delivery of content. Better understanding of PCK shapes how the content is introduced in multiple learning styles to accommodate and modify instructional materials to build on students' prior knowledge. It also attends to inclusive teaching, learning, curriculum, assessment, and reporting. Technology and content affect and inhibit each other (Koehler & Mishra, 2009). Technological content knowledge (TCK) is mastery of multiple subjects and necessary expertise in a specialty. This mastery allows teachers to draw from a range of disciplines to determine the appropriate technologies for the content for deeper learning. Education professionals have to know the specific technologies needed for the particular content and the content required for technologies

(Koehler & Mishra, 2009). Technological pedagogical knowledge (TPK) is using the right virtual pedagogy strategies for the specified learning style. Teaching and learning can change when technologies are employed in innovative ways. Education professionals have to know the minimum and maximum pedagogical range of technical tools. Pedagogical designs and strategies must be cognitively appropriate in regards to the content (Koehler & Mishra, 2009). The technology, pedagogy, and content knowledge (TPACK) framework is an understanding that emerges from interactions among content, pedagogy, and technology knowledge. Teaching with technology requires an understanding of the representation of concepts using various pedagogical techniques. TPACK encourages the use of technologies in creative ways to deliver content, teaching, and learning contexts that work seamlessly together. Teaching successfully with the constant change of technology requires continuous innovation, maintenance, and re-establishing a dynamic equilibrium amongst all components (Koehler & Mishra, 2009). Below is a graphical representation of the TPACK Framework that helps to define technology implementation and an alignment to the concept of STEM programs.

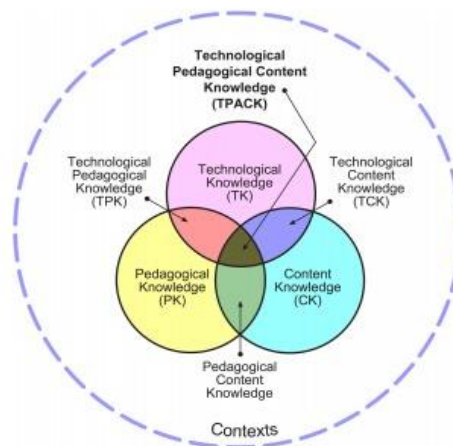


Figure 2.2: Technological Pedagogical Content Knowledge Framework (TPACK). This figure depicts the knowledge and context components that define the TPACK Model (Mishra, P., & Koehler, M. J. 2006).

## **Urban Campus Administrators and Transformational Leadership**

### **Urban Technology Change Agents**

Leading technological changes within schools requires campus administrators to possess an understanding of emerging trends and offering strategic ways to enhance curriculum and instructional development. Focus on innovation is one approach for learning communities to collaborate to share best practices and help students succeed (Garland & Tadeja, 2013).

Technological leadership fosters a domain of professional learning and curriculum development that enables stakeholders to improve student learning through the implementation of contemporary advances and virtual resources. A transformational leadership approach encourages collaborative efforts and communication among individuals from learning groups and ignites the formation of advanced learning (Garland & Tadeja, 2013). As a technology leader, campus administrators must be able to model instruction that is strategic and innovative, while solidifying curriculum expectations and student learning goals (Sheninger, 2014).

**Transformational and Technological Leadership Strategies.** Transformational leaders empower stakeholders in a manner that encourages them to become agents of change. They additionally use an approach that accentuates social change as the reason for individual motivation. It is essential to exemplify authority that is persuasive, such that it empowers stakeholders' development both professionally and personally. The idea of transformational leadership has influenced the field of education since the mid-1980's (Jackson and Parry, 2008; Northouse, 2007). Bass and Avolio (1993) expanded the idea of transformational leadership to include more diverse viewpoints that identified with the sentiments and of both students and teachers. They likewise outlined the key components of (a) idealized influence, (b) individualized consideration, (c) intellectual stimulation, and (d) inspirational motivation. These

components guide the evaluation of the 3 cases in the study, comprised of two each elementary, middle and high school principals.

***The Urban Campus Administrator as Learning and Teaching Motivator.*** School improvement calls for continuous encouragement. It requires the campus administrator to act as the motivator for critical change (Yang, 2014). First, transformational leadership improvement is based on school management ideas. The administrator can provide a model of the school's improvement journey to stakeholders that consist of various improvement objectives through virtual innovation. When a school's vision includes ongoing cultivation and nourishment of its students and adults, the success will depend on transformational leadership (Yang, 2014). A shared vision can ensure the connection of all stakeholders' efforts. Transformational leadership recognizes and strengthens the capabilities of the staff, guiding and managing a shared vision (Yang, 2014). The vision also creates a resilient determination of solidifying school challenges. While understanding and working on the common vision, stakeholders will render increased knowledge, while collectively growing together (Yang, 2014).

***Intellectual Stimulation through Technological Leadership.*** Intellectual stimulation increases one's ability to complete the task, and may promote exciting ideas that inspire students to solve problems. It encourages others to embrace innovation. It ultimately serves as the key part of leaders' encouragement for improvement in the organization by recognizing all members' ability to create interesting new things. Creation of knowledge develops a competitive advantage. It is based on the knowledge that is founded on the thinking-related stimulation and in result thinking-related capital to provide a competitive edge (Yasin et al., 2014). Technology leaders urge stakeholders to consider how they currently implement their work and to consider new methodologies that may help them perform more efficiently. Through investigating different

technological methods and practices, stakeholders may see significance by finding new components and difficulties within their work, thus perceiving that they can apply a broader scope of strategies and information to satisfy job requirements (Peng et al., 2016).

***Idealized Influence of Urban Technological Leadership.*** Idealized influence is a component that is significant to transformational leadership and is particularly on the issues that build stakeholder's trust and assurance through facing challenges. Idealized influence is behaviorally based and maintains authoritative qualities (Yasin et al., 2014). Being a transformational leader requires an understanding of oneself (Finley, 2014). This facet of self-study adds to the conspicuousness of this modern-day theory (Moolenaar et al., 2010). A campus administrator as the transformational leader can align program development with stakeholders' professional and personal interests. As this recognition becomes evident, many stakeholders proceed to align their interests to the virtual shift of the school's environment (Finley, 2014). Such actions allow individuals to collaborate harmoniously through helpful guidance, motivation, intellectual encouragement, or personalized consideration (Finley, 2014). As it relates to STEM, these facets become established when the campus administrator stimulates innovation through technology, coaches and supports staff with continuous professional development, and presents results-oriented achievement steps with models of determination, teamwork, and confidence (Finley, 2014).

***Campus Administrator Transformational Behavior Characteristics.*** Transformational leadership references the behaviors of leaders that encourage higher motivation and increased performance from employees (Vermeulen, Van Acker, Kreijns, & Van Buuren, 2015). It assists campus administrators in structuring their plans to guide school staffs upward and onward. Characteristics of transformational leadership behaviors include idealized influence, inspirational



motivation, individualized consideration, and intellectual stimulation (Balyer, 2012). These are all characteristics of transformational leadership. Each feature contributes to the school staff approval and acceptance, improvements in performance ratings, and job fulfillment (Balyer, 2012). This leadership type is very significant for STEM school staffs who seek to implement modern advancements that align to the evolving societal trends. Teachers' attitudes concerning their principals' transformational leadership behaviors should be positive overall. Regardless of the leader's gender, the transformational leadership behavior results are creating a vision for the school's culture, climate, expectations paired with high levels of performance, agreement of staff goals and academic motivation (Balyer, 2012).

### **Vision for Technology Leadership and STEM Programs in Urban Education**

#### **Visionary Leadership**

A visionary leader is one who inspires individuals to collaborate towards accomplishing organizational goals (Balyer, 2012). Visionary leaders possess a farsightedness about their organization's learning and development. They consider partnerships towards the advancement of the organization. Training is one of the key administration responsibilities (Ismail, 2013). In relation to STEM content, this modality requires cultivating abilities and interest in various fields, driving change, sharpening skills, and investigating results.

Vision provides direction to campuses by articulating the goals and objectives that the leaders' aspire to (Van Knippenberg & Stam, 2014). Vision should include a focus on workplace reforms, adequate funding, and continuous practices to attract students to careers related to STEM in the long term (Van Knippenberg & Stam, 2014). A visionary STEM campus leader can utilize this objective to expand tasks that inspire their stakeholders to become adept at displaying their abilities. Activity, dependability, innovation, and cooperation are qualities that

can be encouraged by leaders with a strong vision (Drago-Severson, 2012). The visionary leader can use these tenants to manage and move the STEM campus towards success at any level (Drago-Severson, 2012).

***Technology Support, Management & Operations in Urban Education.*** There is no escape from the way that technology has effectively changed the world (Sheninger, 2014). The virtual changes in education have opened doors for innovation, quality instruction, and real-world experiences (Peck et al., 2015). Various adjustments in education have expanded learning systems towards creating online and after school practices that seamlessly align to STEM - focused opportunities. These progressions also allow parents and guardians to reinforce school-based instruction, create online projects that are easy to use, and adapt to the virtual changes in demand (Dede, 2014).

***Encouraging Technological Innovation in Urban Schools.*** Educational administration research offers a critical lens for understanding and clarifying how STEM collaboration is implemented at its best. Urban educators can utilize a technology-inspired framework that allows for pedagogy, innovation, and simplicity. The framework has to be presented and encouraged with continuous support and professional development. The more that educators believe the framework is feasible, the more they will deem it to be helpful, and in like manner, more liable they will be to implement it professionally and personally.

### **STEM in the Future**

As STEM programs continue to evolve, their success will depend largely on the ability of educational policymakers to align the programs with the needs of today's workforce (Howard, 2014). STEM programming is essential education reform, meant to strengthen the focus on mathematics and the sciences to prepare students for careers in technology and engineering

(Wilson & Harsha, 2009). Howard (2014) affirmed the need for educational leaders to look ahead to the careers of the future, particularly in technology fields and healthcare that will require employees who are highly literate and skilled in the STEM areas. STEM education is one of many school choice reform initiatives that has been in existence for decades, with substantial resources dedicated to STEM research and improvement initiatives (Howard, 2014). The National Science Foundation (NSF) that was created in 1950 has expended over \$22 billion in STEM research and development to improve the highly focused educational model (Dancy & Johnson, 2008). Real reform according to Drew (2011) must bring about change in eight distinctive areas to improve STEM education. Those changes the author reports are in the areas of leadership, evaluation, teacher improvement, high academic expectations, dedicated mentors and role models, a high value on a college education, commitment to closing the achievement gap and revitalization of university research. Bybee (2010) asserts that the greatest impact for furthering STEM education in today's educational market requires a change in process that is understood and implemented by those directly involved and affected by the reform movement. There are specific elements of the change process that must be employed if the desired goals of any broad-based educational reform are to be reached. STEM education with a "20/20 vision" (Bybee, 2010, p. 6), is one response to current challenges and pressures faced by our nation. As early as the 1950s, this nation faced serious political challenges with potential global impact, and it responded with a science-focused significant curriculum reform movement (Howard, 2014). STEM education that is truly integrated with a strong infusion of technology will motivate young learners and sustain their curiosity about learning throughout their K-12 education (Sanders, 2009).

To that end, new technologies have been introduced in urban education that serves various purposes across the STEM disciplines. Technological innovation within STEM schools helps to shift the thinking, of leadership, staff and students. As change agents, principals must confidently model the latest strategies to their campuses. This requires preparation, professional development, and knowledge of the emerging technologies that are supportive and essential to the future development of students as they pursue today's workforce (Van Knippenberg & Stam, 2014). Many of the latest technologies continue to influence the STEM movement and ignite learning in K-12 districts.

### **Learning Analytics**

Learning analytics is used in STEM education for individualized student assessment data. It includes various information and statistics from different sectors used to improve student retention and provide a more personalized instruction for students. Tools and techniques that are often limited to research laboratories are being implemented by advancing industries to progress decision making to enhance productivity and business gain. This technology is related to STEM education by using data analytics to make informed decisions that drive teaching, increase student and school performance, and close achievement gaps (Baker & Inventado, 2014).

Learning analytics is an emerging STEM field in which sophisticated analytic tools are used to improve learning and education. It is implemented in STEM schools through analyzing academic data through virtual assessments (Jovanović, Gašević, Dawson, Pardo & Mirriahi, 2017). STEM schools can see a real-time snapshot of the learning progress of each student. Also, the real-time snapshot gives educators the opportunity to customize educational activities accordingly (WhiteBox Learning, 2017). For example, virtual assessments consist of dashboards that compute each student's work during the day. That data can be programmed to predict options for

creating a learning plan, monitor progress and manage effort (Saqr, Fors & Tedre, 2017).

Learning analytics for STEM education draws from sectors like business intelligence, web analytics, academic analytics, educational data mining, and action analytics.

Business Intelligence is a well-established practice in the business world where decision makers incorporate strategic thinking with information technology to convert immense amounts of data into powerful, decision-making capabilities (Ferguson, 2012). Web analytics is well-defined as the gathering, analysis, and reporting of website usage by visitors and customers of a website to better comprehend the usefulness of online initiatives and other changes to the website in an unbiased, scientific way through experimentation, testing, and measurement. For example, an important way to gather business intelligence for STEM education involves compiling data from students in which tendencies are noted, hypotheses are formed, and adjustments to the website based on those predictions can be implemented and tested (Rogers, MacEwan & Pond, 2010). Web analytics for STEM education also demonstrates the use of increasingly sophisticated computer-mediated data-tracking, capture and modeling to meet the needs and to predict the future needs of their customers. Analytics software for STEM education might evaluate data mined from assessments to suggest career pathways that might interest students based on a student's location and assessment information. Through these processes, STEM school staffs have been able to provide students with a more personalized, appropriate and well-timed experience that provides the school with a better bottom line (Macfadyen & Dawson, 2012).

Academic analytics for STEM education describes the application of the principles and tools of business intelligence to academia. Academic analytics in the past studied the technological and managerial factors that impact how institutions gather, analyze, and use data.

Currently, academic analytics for STEM education support the study of concerns directly related to education's biggest challenge of student success. Student retention and graduation rates are the two most common challenges measured. Unlike educational data mining that searches for and recognizes patterns in data, academic analytics joins large data sets with statistical techniques and uses modeling to improve decision making (Campbell & Oblinger, 2007). Action analytics is when educators use educational data to act in a forward-thinking manner. Action analytics for STEM education includes setting up academic analytics to produce actionable intelligence, service-oriented architectures, mashups of information/content and services, supported models of course/curriculum reinvention, and changes in faculty practice that improve performance and reduce costs. Action analytics can create actionable intelligence on student performance based on data captured from a variety of systems. The mission is to improve student success.

### **Mobile Learning**

Mobile learning in STEM education expresses the delivering and facilitating of STEM education through mobile devices. Mobile learning is related to STEM education because it drives student interest. Mobile learning for STEM education is implemented through active engagement with hands-on learning that includes authentic scientific tools, one of the most efficient ways for students to learn and retain science knowledge (Bayer Corporation, 2015). Mobile learning is executed in STEM schools through three current trends. The three current trends in mobile learning are remote labs, personal learning environments, and portable devices (Jones & Stapleton, 2017). The experience of remote labs and teleoperated experimentation can be delivered to the STEM learner by technically and didactically integrating the labs into collaborative learning systems like monolithic learning and content management systems, or cloud-based personal learning environments. Personal learning environments are educational

technology which can respond to the way people are using technology for education and which allows them to shape their learning spaces themselves, to form and join communities to generate, consume, remix, and share material. Personal learning environments provide more responsibility and more independence for STEM learners. STEM learners can point towards redrawing the balance between institutional learning and learning in the wider world. Personal or mobile devices are perhaps the most rapidly growing category of technology for informal learning environments. The increasing diffusion of portable devices such as tablets PCs, laptops, and smart mobile phones offer an increasingly valuable potential to support new ways of self-directed, informal and creative learning anytime and anywhere (Zubía & Alves, 2012).

STEM learners do not learn in privacy and isolation. They learn together with their peers and teachers. STEM learners absorb knowledge and information while competing and collaborating. For example, learners acquire by doing and improving misunderstandings they have from previous learning activities. They learn within a well-defined learning environment. In the past, STEM learning was constrained within classroom walls, and the teacher was the principal holder of knowledge. With the emergence of computers, the teacher now competes with material outside the school and beyond his/her control. Instruction must therefore be changed (Bransford, Brown & Cocking, 1999; Brown R., Brown J., Reardon & Merrill, 2011; Koschmann, 2001). The concept of STEM learning mobility revisits what learning means and what are its ingredients. Components of the STEM learning environment are the learner with the engineering notebook and virtual portfolio. They are involved with a teacher acting as the facilitator and coach. There is access to e-books and online tutorials within a structured curriculum with predefines tasks and targets as well as methods of interaction. The STEM

learner is a member of a learning community within which she or he competes in project-based learning and cooperates in logistics and learning.

The STEM learner in the mobile learning environment may have access to a multitude of different handheld devices. This learner is also surrounded by physical and digital media in which antennas, repeaters, servers and other technical equipment may continuously change. A mass of managing, negotiation, monitoring, and maintenance processes run in sync. Much of these logistics directly affect the quality and efficiency of learning. They must, therefore, be treated as an integral part of the STEM learning process. What moves with the student must no longer be the device, but the STEM learning environment. What remains distributed will be the various knowledge applications and of course the raw data. Mobility is about growing a STEM learner's competence to physically move their learning environment as they move (Barbosa & Geyer, 2005). The mobile context permits constructivist approaches to be employed and contextual learning to occur. Now, it is possible to take the STEM learning process out of the classroom into authentic environments.

### **Online Virtual and Remote Learning Laboratories**

Online virtual and remote learning laboratories motivate more young people to choose STEM as their future career pathway to keep the future economy competitive (Atkinson & Mayo, 2010). Scientific inquiry in their STEM courses is needed. Online virtual and remote learning laboratories are STEM-related due to internet applications that compete with realistic labs that give students practical hands-on experience to perform experiments in a practice setting without the use of physical components (De Jong, Linn & Zacharia, 2013). Scientific inquiry skills are learned in the context of online virtual and remote learning laboratories implemented to teach students those skills and allow teachers to illustrate the scientific theory. Inquiry learning



leads students through various phases of STEM education. Students go through steps of orientation, conceptualization, investigation, conclusion, and discussion (Pedaste, Mäeots, Siiman, De Jong, Van Riesen, Kamp & Tsourlidaki, 2015). Students create hypotheses, evaluated through experiments and then reflected. Students repeat the typical engineering design process. This type of learning shows benefits over standard lectures or demonstration labs (Govaerts, Cao, Vozniuk, Holzer, Zutin, Ruiz & Tsourlidaki, 2013). Even though it is popular, a widely-used online lab portal integrated with a ready-to-use learning environment is still missing. Typical individual online labs are operated, maintained and promoted by the lab owners, which causes a high operational cost and limited access. Online virtual and remote learning laboratories aim to establish an alliance of online labs where lab owners can advance their labs, and teachers can find labs to support their activities and share their resources with others. The goal of functional labs is to provide resources, not to replace teachers. Such a lab empowers student learning where teachers to help and assist students who learning and applying STEM concepts (Govaerts et al., 2013).

## **Gaming**

When engaged in gaming, students become connected to the real world. They learn to work collaboratively and to answer problems through the highly complex mental challenges that games offer. Students also cultivate resources and skills that transfer into future learning opportunities (McElhany, 2016). Gaming can be implemented to improve topics in STEM-related disciplines (Wu & Anderson, 2015). Gaming possesses the latest possibility to redefine and reshape educational and instructional practices. Gaming is related to STEM education because it is redefining education by increasing students' analytical thinking, team building, multitasking, and problem-solving skills. Gaming has the potential to develop the skill set that

prospective employers want (Clark & Ernst, 2009). It possesses the ability to inspire struggling students in danger of dropping out of school. Initially, the idea of using video games to teach STEM seems questionable to some. Learning benefits of gaming appear when effective pedagogical practices are embedded in the game design. Many of these same practices can also be applied to the classroom or other forms of instruction with similar benefits. This approach is known as game-informed learning (Begg, Dewhurst & McLeod, 2005).

Educational games are an engaging way to enhance STEM instruction. In a top-rated STEM video game, students learn how to prevent the spread of infectious diseases. In Filament Games' (2017) award-winning UDL-based STEM video game "You Make me Sick," players are challenged to engineer a bacteria or virus based on the unique attributes of different human hosts. The STEM game provides varying levels of challenges that appeal to a broad range of students. Students can choose from existing bacteria, such as salmonella, or they can engineer their own. The game takes the player from a virtual macro-level view of the environment. An example included the inside of a kitchen owned by a person with less than ideal health and hygiene habits. Through this visualization, students can understand the infection process better. As the game progresses, players are virtually transported inside the human body, through the bloodstream, to a microscopic level where they infect a cell while being chased by white blood cells. This type of technology enhanced STEM instruction provides students with a conceptual understanding of how diseases are spread and, thus, how they can be prevented in a way that was unobtainable in the classroom just a few years ago. STEM game-based learning has the potential to deliver STEM education to millions of users simultaneously. Unlike other mass-media experiments in the teaching like television and webinars, games are a highly interactive medium with many key attributes shared with sophisticated pedagogical approaches. Large-scale adoption, however, still

awaits key infrastructural developments to improve the quantities of users, quality of the product, and sustainability of business models (Kapp, 2012).

### **Wearable Technologies**

Examples of wearable technologies for STEM education are smart watches, cameras, Google Glass, fitness trackers like FitBit, and virtual reality headset system like the Oculus Rift. Users wear wearable technology devices to collect, access data and control other devices. It comes in the form of an accessory disguised as jewelry, sunglasses, a backpack, or pieces of fashion like shoes or a coat. Wearable technology usefully integrates tools that track sleep, movement, location and social media. Devices are effortlessly united with a user's daily life and activities. For example, Google's Project Glass was a hit back in 2013. Google's Project Glass is described as eyewear that delivers info about the surroundings including friends that are near. Robots and drones own the indisputable motivating factor in STEM education, but the same can certainly be said for art and fashion. An electronic textile (E-textile) is a form of cloth that has electronic elements. The development of electronic textiles supports the idea of wearable computing, or electronic devices worked into garment designs. E-textiles range from the development of lively stuffed animals to smart t-shirts. E-textiles are related to STEM education because they allow communications with a user's devices via sewn in controls or touch pads that collect data on movements and much more (Bower & Sturman, 2015). Students can take in the principles of electrical engineering while sewing together circuits with conductive thread. As a solution, E-textiles are implemented as a method of engaging middle schoolers. The target consists of middle schoolers living outside of the usual tech-loving demographic. E-textiles boost the concepts of the STEM subject computer science. Computer programming is a major component of designing wearable e-textile design and designing wearables has great educational

potential. A device like the LilyPad Arduino can be programmed to control the electrical signals sent through the thread-based circuitry (Arduino, 2017). LilyPad Arduino is a STEM kit used to implement electronic textiles. The LilyPad Arduino is a small programmable microcontroller based on the popular Arduino board. The LilyPad was made to look like a futuristic water lily, with a purple circular printed computer board (PCB) with conductive holes around the edges that move electricity through silver nylon thread. This conductive thread can be connected to input, output, and a wide range of sensory devices and is used to connect a power supply to the LilyPad (Arduino, 2017). The kit focuses on students solving real world problems and practicing the engineering design process while immersed in the innovative area of wearable technologies. LilyPad Arduino is designed specifically for soft circuit projects. The kits are relatively cheap, painless and available for bulk purchases for STEM education (Arduino, 2017).

### **Global e-Learning Implications**

Online connectivity is shaping the world's economic and social standing. Internet accessibility by way of wireless access points, a mobile network, or a grounded broadband connection provides individuals the ability to connect to an online experience that is growing daily. Work in energy-related careers will expand during the next decade, as STEM jobs increase by 17%. New occupations will grow at a projected 9.8% according to the Department of Commerce (Gillibrand & Kennedy, 2014). The Internet has provided organizations a way to sell their products through e-commerce domains and for users to stay connected with information through social media and learning opportunities both professionally and personally. The benefits alone display the impact the Internet has had on those fortunate enough to be a part of the online infrastructure. The growing importance of STEM jobs in the U.S. economy is evident. In 2014, the U.S. federal government paid \$3.1 billion for STEM education programs through various

federal agencies, an increase of 6.7% over the 2012 funding levels (Gillibrand & Kennedy, 2014).

According to a report by McKinsey & Company (2014), there were 4.4 billion people that were offline worldwide, and 3.4 million of those individuals lived in just twenty countries. People without Internet access may experience that disservice as preventing them from reaching a higher economic standing, education, social mobility, or other benefits that may help improve overall life circumstances. This is not just a problem for the underprivileged but for many students, whether they are connected or not. Those who are not connected cannot make contributions to help better the world until they are provided accessibility or the opportunity for acquiring the necessary skills that today's industries are seeking.

If STEM education is to be a response to the need for better-prepared students for our technological workforce, parents and teachers must support a shared understanding that every child has the potential to learn mathematics and science and that these subject areas need to be taught to all students (Olson, 2014). This belief, as stated by Drew (2011), "must also be shared with students regardless of affluence, gender or ethnicity." Cavanagh (2008) proclaims that policymakers will need to align programs with the specific requirements of the workforce that are slated to expand in the future. Examples of those career options are in the areas of healthcare and technical support services that will require students to be educated in the core areas of literacy and the sciences. Some labor experts believe that educational decision makers must communicate better regarding careers that are on a growth trajectory thus allowing on-going discussion between educators and personnel to occur (Cavanagh, 2008).

## **STEM Program Sustainability**

One aspect of STEM education that makes it unique from other types of academic study is the school schedule, which typically incorporates expanded blocks of time for interdisciplinary study and time for teachers to plan together (Howard, 2014). Cavanaugh (2008) references a strategy that has been used in recent years to promote STEM schools. The targeting of school-wide populations through changes in graduation requirements that increase the number of science and math courses all students would be required to take to earn a high school diploma. He reported that between 1989 and 2006, states increased on average the course requirements for math (.8 course credits) and science (.7 course credits) necessary for successful completion of high school. By the 2007-2008 academic year, a minimum of 35 states required at least three years of science and math and forty-eight states had implemented some technology standards (Cavanaugh, 2008).

Brown et al. (2011) described successful STEM programming as an interrelated, experiential model involving all four disciplines and is required for every student. The U.S. Department of Education (2008) further supported the need for staff development and training, community partnerships, program recognition, school board support, funding sources are all elements of STEM program sustainability. Studying and conducting research on ways that students learn, and gaining an understanding of integrated curriculum are critical components of a successful STEM reform movement (Dancy & Johnson, 2008). The U.S. Department of Education reported that integral to any school's success, regardless of the theme, is planning, implementation, phasing and integrity of the vision and mission when confronted with challenges that could jeopardize program sustainability (U.S. Department of Education, 2008).

## Summary

Exploring technology implementation and STEM programs through the lens of the ISTE Standards for Administrators suggests the importance of school leaders becoming technologically equipped with cutting edge leadership practices. Innovative, non-customary technological modalities will continue to emerge throughout the next decade, in both amount and quality. Inside the urban school system, technology has contributed long range communication, learning management systems, virtual pedagogical frameworks, and various resources that make learning conducive at any time. Online learning practices have quickly become more prominent with learners, which support the adaptability requested by campus administrators who pursue the full-time profession and adhere to state and federal objectives. The extent of this analysis addresses the development of customary stakeholder-driven situations towards technology implementation and the need for student career preparation through STEM programs. The analysis elucidates how these implications will influence virtual learning in the forthcoming years. Chapter 3 will provide the methodology blueprint for exploring the perceptions of principals about STEM program sustainability within this Texas Urban School District.

## **CHAPTER THREE**

### **METHODOLOGY**

The purpose of this qualitative study was to describe the perceptions of urban district principals regarding technology implementation and identify recommendations for the sustainability of STEM Programs within this Texas Urban School District. Chapter 3 expounded on this study's design, research questions, methods utilized to conduct the study, and sampling techniques, that were used. The research questions that guided this study were:

1. What are the perceptions of principals regarding the implementation of technology within urban schools?
2. What are the perceptions of principals regarding the sustainability of STEM programs within urban schools?
3. How do urban principals develop knowledge about STEM education?
4. What are the perceptions of principals regarding barriers to learning for STEM students?

#### **Setting**

Located in Southwest Texas, this Texas Urban School District encompassed an area of 333 square miles and also represents the seventh largest school district in the United States. This education organization serviced students in 282 campus locations, including seven campuses located in a recently annexed suburban area. The district's headquarters at the [name] Educational Support Center is located in northwest [name]. This geographic diversity is reflected among the approximately 210,000 students in the district who speak over 100 languages. The district's offices operated under the supports of the Texas Education Agency, Texas Essential Knowledge and Skills for prekindergarten through twelfth grade. Instructional offerings and



training included magnet and vanguard programs, charter schools, and alternative programs that used innovative instruction to help at-risk students of dropping out of school. Also offered were curricula in career and technical/ vocational education, early-childhood education, special education, multilingual education, and dual credit/ advanced academics.

### **Research Sample**

Within this Texas Urban School District, The Office of School Leadership Department was a collaborative, internal, organizational effort guided by the work of the Human Resources Department. This collaboration was a reflection of the district's "Grow Your Own" Model and comprehensive leadership development programs that addresses the needs of campus leaders at every state of the leadership development pathway process. The department's mission focused on developing highly effective leaders who increased student achievement for every student within the district. The participants of this study were able to speak to the training that was specific to STEM education and described how they evaluated the needs of their campus regarding technology implementation and continuous support.

Using purposeful sampling, this study included six STEM campus principals from the elementary, middle, and high school levels, as administrators supported by The Office of School Leadership. Purposive sampling is a non-probability sample that was selected based on characteristics of a population and the objective of the study. It is also known as judgmental, selective, or subjective sampling (Creswell, 2013). The principals of this study were selected from the Texas Urban School District STEM campuses and were referenced as: Elementary Principal 1, Elementary Principal 2, Middle School Principal 1, Middle School Principal 2, High School Principal 1, and High School Principal 2.

Semi-structured interviews were conducted by telephone. This type of interview was a qualitative method of inquiry that combined a pre-determined set of open questions with the opportunity for the interviewer to explore particular themes or responses further (Creswell, 2013). Appendix C provides a sample of the interview guide with the interview questions that align to the ISTE National Educational Technology Standards for Administrators, Distributed Cognition, and the Transformational Leadership Theory.

### **Data**

The phenomenological study is an approach to qualitative research that focused on the commonality of a lived experience within a particular group. The fundamental goal of the approach was to arrive at a description of the nature of the particular phenomenon (Creswell, 2013). Creswell (2013) asserted that phenomenology studies can include various sources of data such as: documents, archival records, interviews, observations, and physical artifacts (p. 106). Because comparisons were drawn, it was imperative that the principals were chosen carefully so that the researcher could predict similar results, or predict contrasting results based on a phenomenon (Yin, 2003). As stated previously, this study employed forty-five minute semi-structured interviews with face-to-face and telephone options to answer the research questions. Semi-structured interviews consisted of several key questions that defined the areas being explored, but also allowed the interviewer or interviewee to diverge to pursue an idea or response in more detail (Creswell, 2013). The interviews allowed the principals to describe the virtual resources as technological artifacts, which promoted technology implementation within an organizational setting. This process in turn was then aligned to the concept of distributed cognition. As it related to the principals' perceptions, the responses addressed idealized influence, individual consideration, inspirational motivation, and intellectual stimulation, which

was redolent of the Transformational Leadership Theory. Interviews are frequently used in educational research to collect data about phenomena that are directly observable, such as personal experience, opinions, values, and interests, as well as similarities across these phenomena (Gall, Gall, & Borg, 2007).

The interviews with the principals were recorded and transcribed using the application Recordator. This cloud-based application allowed for phone call recording and transcription services within one area (Recordator, 2017). Recording the interviews also allowed for data collection by the researcher and transcription that aided in presenting an unbiased view of the data. During the interviews, the researcher took notes in addition to the audio recordings.

### **Analysis**

To collect the data and to preserve the identity of the principals, the researcher began by assigning an abbreviation. This abbreviation was used to conceal the principals' identity and to represent the school level that was being investigated (for example, ESP 1, MSP 1). Next, the comparisons between the principals was analyzed, which allowed for comparisons of the roles and responsibilities of the different campus principals regarding technology, and their perceptions of STEM program sustainability at their urban campus. Based upon the interview transcripts from the six principals, the researcher utilized emotion coding and value coding to identify the segments of data that were relevant to answering the proposed research questions (Saldana, 2013). Creswell (2013) explained that "open coding allows the researcher to be as expansive as possible and provides the platform for identifying distinct concepts and categories that derive from the data" (p. 178). These categories were abstractions from the data and ultimately had a life of their own apart from the data from which they were derived (Creswell 2013, p. 181). Emotion coding and value coding explore the inner cognitive system of

participants. Emotion coding, quite simply, labels the feelings participants experienced (Saldana, 2013). Value coding assesses a participant's integrated value, attitude, and belief systems at work (Saldana, 2013).

After exploring the transcripts, the researcher utilized the software NVivo to import the transcripts and used the research questions to construct categories. NVivo is qualitative data analysis software that supports annotating, coding, and retrieving the analysis of documents and images. In regards to this research, the interview transcripts derived from responses of the six participants (Cuva, 2014). Creswell (2013) defined categories as conceptual elements that cover or span many individual examples or units of the data previously identified (p. 181).

After the categories were created, the researcher sorted the evidence in NVivo. Marshall and Rossman (2006) defined these categories as “baskets” or “buckets” where segments of text are seated (p. 159). All of the text was placed in electronic file folders using the Google Drive Application provided by The University of New England and included the participant’s name, and line numbers of the excerpt. In doing this, the researcher was enabled to revisit the original transcript to review the context of any quote (Creswell, 2013, p. 182).

Finally, the researcher used NVivo to create four tables for elementary, middle, and high school levels. This ensured that the information captured was consolidated to satisfy the above research questions (Creswell, 2013, p. 176). The themes that emerged from the elementary, middle, and high school principals were compared to identify recurring topics within the data.

### **Participant Rights**

Prior to the interview, the principals within each of the six STEM schools received an informational letter, which introduced the researcher, the importance of the study and the purpose of the study (Creswell, 2013). The Informational Letter served as the formal invitation

for principals to participate in the interview process (Appendix A). The principals who agreed to participate were presented with a consent form for participation, which aligned directly with the guidelines set forth by the University of New England. The Consent Form for Participation further informed principals that their involvement with this study was strictly voluntary. Contact information for the researcher and the university advisor was provided on the consent form. Principals were informed within the letter and the consent form that their names would not be used within the written documentation of this study. The identity associated with the principals responses to the interview questions was not be revealed before, during, or after the study was conducted. A copy of the Consent Form for Participation can be viewed in Appendix B.

### **Potential Limitations**

A challenge with homogeneous purposive sampling was the probability of researcher bias and the task of generalizing research findings (Palinkas, Horwitz, Green, Wisdom, Duan, & Hoagwood, 2015). Each sample was based entirely on the judgment of the researcher in question, who was narrowing the scope of the study (Palinkas et al., 2015). For this reason, researchers strive to make decisions based on established criteria, not on what will best support the personal theory (Palinkas et al., 2015). In following this process, the potential for bias is lessened.

Creswell (2013) asserted that constructing theme categories poses the potential challenge of identifying a recurring pattern that cuts across the data from the study (p. 181). Furthermore, Creswell (2013) explained that categories should be responsive and answer the proposed research questions; be as sensitive to the data as possible; be exhaustive enough to encompass all relevant data; be mutually exclusive to where data can be placed in one category; and be conceptually congruent across all categories

## Summary

The purpose of this qualitative study was to describe the perceptions of urban district campus administrators regarding technology implementation and to identify recommendations for the sustainability of STEM Programs within this Texas Urban School District. Multiple case study analyses were applied and captured the perceptions of campus principals as they related to technology implementation and the sustainability of STEM education programs. Three principal case studies explored the perceptions of six principals, while uncovering the emerging themes that derived from six participant semi-structured interviews.

The results reflect principals' perceptions that STEM education programs and technology implementation is a vital component within this Texas Urban School District. A second assumption was that principals had perceptions about the continuum of STEM education programs, as they are charged to address the growing disconnect between the skills that employers need in a rapidly increasing technological world. Urban principals will attend various professional development initiatives and also build community relationships and partnerships with businesses in the region. Principals also perceived that a reduction in campus budgets, STEM education experienced staff members, and the unawareness of technological resources available outside of school could create barriers of learning for STEM students.

The responses provide sustainability strategies that could be considered by decision makers as solutions to improve existing urban school virtual and STEM education program practices when presented with budget constraints and reductions in staff availability. The results of this research study will assist in the continuous development of the Office of School Leadership School Leader Initiatives and added additional research data to state-wide studies in Texas. The study results are explained in detail in Chapter 4.

## **CHAPTER FOUR**

### **RESULTS**

The purpose of this qualitative study was to describe the perceptions of urban district principals regarding technology implementation and identify recommendations for the sustainability of STEM programs within this Texas Urban School District. Leaders must establish a clear vision while executing a process that includes technological savviness, global awareness, communication, stakeholder engagement, and innovation. This study focused on principals, as they are the individuals who decide upon the technology education learning initiatives at the campus level. The tenets of STEM and technology implementation are interwoven and work together to build a bridge to prepare students for today's workforce industry. The research questions that guided this study asked:

1. What are the perceptions of principals regarding the implementation of technology within urban schools?
2. What are the perceptions of principals regarding the sustainability of STEM programs within urban schools?
3. How do urban principals develop knowledge about STEM education?
4. What are the perceptions of principals regarding barriers to learning for STEM students?

#### **Analysis Method**

The researcher's objective was to identify factors relevant to four research questions as reflected in six interviews. The semi-structured interviews were conducted with STEM principals, with two of each representing the elementary, middle, and high school levels. This type of interview is a qualitative method of inquiry that combines a pre-determined set of open

questions, with the opportunity for the interviewer to explore particular themes or responses further (Creswell, 2013). The interviews were conducted by telephone using the cloud-based application Recordator to capture the transcripts immediately thereafter. Forty-five minutes was allotted for the interviews with each lasting thirty minutes on average. Because the phenomenological study utilized a semi-structured interview process with open-ended questions, the researcher was able to probe participants for further information when necessary. The interview process also allowed the researcher to ask follow-up questions when participants shared unexpected information.

### **STEM Principals' Background**

Elementary Principal 1 was a 41 year old female with nineteen years of experience in education and was in her first year as a principal on an urban STEM campus. She was very enthusiastic about participating in the study and extremely adamant about motivating more female students to pursue an interest in STEM. Her vision is one that is inclusive of campus and community stakeholders to leverage STEM resources for student success.

Elementary Principal 2 was a 43 year old male with seventeen years of experience in education and five years' experience on an urban STEM campus. His campus had already transitioned from STEM to STEAM (adding the arts component) and included the community in school planning and instructional activities. He expressed how STEAM was evolving and that it required all stakeholders to be included in the school's vision.

Middle School Principal 1 was a 49 year old female with twenty-three years of experience in education overall and two years of experience at an urban STEM campus. She served at other STEM campuses as an assistant principal and watched STEM education flourish through the years. Like Elementary Principal 1, she was a huge supporter for empowering female



students to pursue the career pathways that align to STEM. Her vision includes exposing students to various real-world concepts that model the possibilities surrounding STEM careers.

Middle School Principal 2 was a 47 year old male with eighteen years of experience in education and two years of experience as principal at an urban STEM campus. He stressed the importance of connecting STEM campuses together to leverage the sustainability of the programs and to provide increased options for students. His vision is one that includes campus and community stakeholders but also invites previous students to return to share their successes as they pursue STEM pathways.

High School Principal 1 was a 44 year old male with eighteen years of experience in education and four years of experience at an urban STEM campus. Like Elementary School Principal 2, his vision included a very strong alumni pool with various community supporters and business partnerships. He stressed the importance of these relationships and consistently changes his campus plans to ensure the inclusion of all stakeholders.

High School Principal 2 was a 53 year old male with twenty-six years of experience in education and seven years of experience at an urban STEM campus. He was proud to speak about his students obtaining licensure in welding, dental services, medical transcription services, automotive technology, and associate's degrees by graduation. He was also passionate about his vision in which school leaders seek to prepare students for the increasing demands of today's workforce. More supporting evidence will be revealed in the analysis portion of this chapter.

Table 1 renders a brief demographical overview of each principal's background.

Table 4.1

*Demographics of STEM Principals*

<b>Principal</b>	<b>Gender</b>	<b>Age</b>	<b>Years in Education</b>	<b>Years as an Urban STEM Principal</b>
Elementary School 1 (ESP 1)	Female	41	19	1
Elementary School 2 (ESP 2)	Male	43	17	5
Middle School 1 (MS 1)	Female	49	23	2
Middle School 2 (MS 2)	Male	47	18	2
High School 1 (HS 1)	Male	44	18	4
High School 2 (HS 2)	Male	53	26	7

Common themes were identified across the data with regards to addressing the research questions. The process of data analysis involved “making sense out of text and data and preparing the data for analysis, conducting different analyses, representing the data, and making an interpretation of the larger meaning of the data” (Creswell, 2009, p. 183). The researcher looked for patterns, themes, and dimensions in the data through analysis of the interviews, coding of the data, and further analysis as themes and patterns emerged. The researcher’s goal was to describe the perceptions and views of the principals from the elementary, middle, and high school levels. Appendix C provides a sample of the interview guide that was used to conduct the interviews.

The first level of identification occurred during the initial review of each interview transcript. Upon receiving the transcripts from Recordator, the researcher read each transcript, analyzed the data for each interview, and then conducted open coding utilizing NVivo software, which is an analytic tool to facilitate the coding process.

The researcher used open coding that utilizes a brainstorming technique described by Corbin and Strauss (2008) to “open up the data to all potentials and possibilities contained within them” (p. 160). In open coding, the researcher thoroughly reviews the data contained within the data set before beginning to group and label concepts. The process of coding is taking the raw data and pulling out concepts and then further developing them in terms of their properties and dimensions and grouping them into themes. The data analysis process included the following steps:

1. Review all interview transcripts
2. Import the data documents into NVIVO
3. Code the data in NVIVO using open coding
4. Define the properties of the dominant themes
5. Create categories that represent major and minor themes

The resulting themes were described in the analysis results.

### **Coding**

The coding process identified a total of 19 primary themes. The themes were delineated into four areas, with each area focusing on one of the four research questions. The findings for each research question are summarized and examples from the interviews were used to illustrate the themes. The analysis results section includes tables displaying the definition of the identified themes, the frequency of occurrence of the themes, and the number of interviewees that mentioned a specific theme.

## Presentation of Results

The presentation of results began with an identification of the research questions. The analysis was explained in detail and was followed by the themes that emerged from the principals' responses. Tables are provided to present the themes and definitions of each research question. Evidence was presented in the form of principal comments, which supported the researcher's identification and explanation of each significant theme.

### Research Question 1

Research Question 1 asked, what are the perceptions of principals regarding the implementation of technology within urban schools? There were five themes related to this research question. As reflected in Table 2, the themes were *STEM skills and technology for students are imperative, students must have hands-on STEM experience, more STEM technology is needed, exposing students to STEM early sets the stage, and engaging and empowering girls in STEM is important*. Appendix D shows the frequency with which the themes appeared across interviews and across the data for research question 1. The principals provided quotes that aligned with the specific themes and are represented by ESP 1, MSP 1, and HSP 1.

Table 4.2

#### *Themes for Research Question 1*

Theme
STEM skills and technology for students are imperative
Students must have hands-on STEM experience
More STEM technology is needed
Exposing students to STEM early sets the stage
Engaging and empowering girls in STEM is important

## **Theme 1: STEM Skills and Technology for Students Are Imperative**

The most frequently occurring theme for Research Question 1 was *STEM skills and technology for students are imperative*. This theme explains that the elementary, middle, and high school principals perceived technology implementation and STEM skills to be imperative in urban schools regarding preparation for the workforce and for future skill development. STEM skills for students are imperative were mentioned 14 times in 6 interviews. STEM education matures students to have the eagerness to be involved in problem solving and with the concepts of STEM education as a constructive, concerned, and reflective citizen (Bybee, 2013).

### **STEM Elementary School Principals**

STEM elementary school principals reported that technology skills for students were imperative and that exposing students to STEM early sets the stage for students as they progress. The following quote articulated this finding. ESP 2 mentioned:

I think the implementation of technology is significant when you look at careers, and the careers of the future; even the careers of right now and the type of thinking that kids are going to have to do; the types of collaboration that they're going to have to do in groups. Being at a STEAM campus or STEM campus, you must collaborate; you must do research; you must be ready when presented with a problem and try to solve that problem. These are all things that we do at our STEAM Magnet, coding and writing; being able to write and express oneself in written format; being able to make an assertion and backing up with evidence.

### **STEM Middle School Principals**

STEM middle school principals reported that technology skills for students were imperative and that exposing students to STEM early sets the stage for students as they progress.

The following quote articulates these findings. MSP 2 indicated:

Two High Schools have the airport for logistics and transportation. It provides technology camps and internships for students. Students are even able to obtain their pilot's license. So, programs are as strong as the resources are at the campus. This is why technology implementation is so vital. Companies don't have the time to partner up with schools that aren't producing anything. They want students to be able to come out of school being able to go and do great things. As a compliment to one of my teachers who is a medical doctor in another country but not recognized in the United States, all of his students go to Jones with regards to being technologically savvy. They are leaps and bounds ahead of those students in rural schools. Technology is definitely a vital component and huge necessity at my campus.

### **STEM High School Principals**

STEM high school principals reported that technology skills for students were imperative and that exposing students to STEM early sets the stage for students as they progress. The

following quote articulated these findings. HSP 2 shared:

Here on our campus we have various technology components that are based on engineering and science. So, with our STEM program, we foster areas of learning for students who are interested in engineering and various other areas that align to STEM and utilize technology immensely. We have graduates from agriculture, construction, and computer science, which are STEM related and provide students more exposure to STEM

components. This fosters a foundation for them, and if they are able to go to college hopefully they will find something a little bit more intriguing. They will at least have the beginning skillset to be exposed to the areas of STEM that can provide some type of continued education.

## **Theme 2: Students Must Have Hands-On STEM Experience**

The next theme for Research Question 1 was *students must have hands-on STEM experience*. This theme defined the elementary, middle, and high school principals' perceptions that it is important for students to have real world hands-on experiences involving STEM. Students must have hands-on STEM experience was mentioned 8 times in 4 interviews. Hands-on activities that are project-based can improve student understanding of STEM topics dramatically, and laboratories are the most common implementation of hands-on learning (Connor, Ferri, & Meehan, 2013).

### **STEM Elementary School Principals**

STEM elementary school principals reported that students must have hands-on STEM experience and that it is important for them to have real world hands-on experiences involving STEM. The following quote articulated this finding. ESP 2 mentioned:

Our school started off as a science program and we did not receive any extra funds. We have been blessed to be able to utilize what we have in lieu of this situation. We are actually growing in leaps and bounds with regards to our students being able to experience those real-world experiences regarding STEM through field trips, camps, symposiums, and career days. We even have a week where we highlight specific areas of STEM each day.

### **STEM Middle School Principals**

STEM middle school principals reported that students must have hands-on STEM experience and that it is important for students to have real world hands-on experiences involving STEM. The following quote articulated this finding. MSP 2 explained:

There are some things that I'm trying to do, and I'm just going to have to be patient because we have a full-blown clinic at our school. Unfortunately, it hasn't been used because we have to find a partner that can come in and teach the students how to conduct patient care. We have a room in our school with five beds, five scales, five blood pressure monitors, five partitions, and five CPR dummies but I need somebody to partner with the school. Just like Baylor in Third Ward, I want somebody to partner with our school so our students can see and experience the real word concept. It can be Methodist or St. Luke. I've been having this conversation with a lady that's been really tough, but hopefully I can encourage her to come in and just visit the school to see what we have to offer.

### **STEM High School Principals**

STEM high school principals reported that students must have hands-on STEM experience and that it is important for students to have real world hands-on experiences involving STEM. The following quote articulated this finding. HSP 2 explained:

First, it's going to be tough. I mean, just making sure that our students have what they need as far as what the State of Texas is saying that they need in place for them to be able to complete their high school education is vital. Additionally, I've been tasked with preparing the students to be able to complete at least sixty hours of their college education. So, you can see that I have a heavy academic weight on my shoulders. I want



to use the STEM channel as an enhancer to accentuate the learning because what it does is provide hands-on experience for students at the turning point of them transitioning into adulthood. It's going to help our kids make the hands-on connections like the tactile, kinesthetic connection to things. It helps to answer some of the difficult things that they're learning about in math, science, and engineering.

### **Theme 3: More STEM Technology is Needed**

The next theme for Research Question 1 was *more STEM technology is needed*. This theme defined the elementary, middle, and high school principals' perception that more technology should be implemented in urban schools. It was mentioned 4 times in 4 interviews. Today's youth must receive an array of technological and educational experiences that enable them to develop the full range of skills needed to adapt to the jobs of tomorrow and succeed in the STEM economy (Flynn, 2017).

#### **STEM Elementary School Principals**

STEM elementary school principals reported that more STEM technology is needed and that it should be implemented within urban schools. The following quote articulated this finding. ESP 1 explained:

We could actually use more technology here at my campus. One thing that I hope to see is more of our computer labs to become more efficient and for us to get more updated technology. As you actually look at the levels of technology, it is a lot different at the high school level versus the middle school and elementary levels.

### **STEM Middle School Principals**

STEM middle school principals reported that more STEM technology is needed and that it should be implemented within urban schools. The following quote articulated this finding.

MSP 1 explained:

I believe that up to date technology is critical when you talk about a STEM or STEAM campus. I think it should play a major role in schools period. Enhancing technology implementation in the learning of the classroom teacher and at the urban campuses is a key to success for students at all campuses. There is no getting away from that.

### **STEM High School Principals**

STEM high school principals reported that more STEM technology is needed and that it should be implemented within urban schools. The following quote articulated this finding. HSP 1 explained:

The perception is that a lot of schools offer some of the same things but unfortunately, it takes away from neighborhood schools. This means that we have the technology at the high school level but there could be more and this comes with increased funding. So, if you're right here in my community but another school on the other side of town offers something similar with a better environment, then the students will go there. It just takes away from a lot of students that are actually zoned to us.

### **Theme 4: Exposing Students to STEM Early Sets the Stage**

The next theme for Research Question 1 was *exposing students to STEM early sets the stage*. This defined the elementary, middle, and high school principals' perception that exposing students to STEM early in their education sets the stage for students as they progress. It was

mentioned 4 times in 3 interviews. A robust K-6 foundation is required to make STEM learning more comfortable for children (Born, 2018).

### **STEM Elementary School Principals**

STEM elementary school principals reported that exposing students to STEM early sets the stage for students as they progress. The following quote articulated this finding. ESP 1 explained:

Our workforce is changing each and every day. We must hone in more on those skills that are applicable to the STEM content. And so, it starts at this level, at the elementary level, and it actually carries on up until they get to the twelfth grade and beyond. We are the foundational piece that actually helps to prepare those skills and help students decide the direction that they would like to pursue. STEM provides our students with a wealth of options that they can hone in on and pursue.

### **STEM Middle School Principals**

STEM middle school principals reported that exposing students to STEM early sets the stage for students as they progress. The following quote articulated this finding. MSP 1 explained:

So the issue is going to be when the district starts to discuss about the student demographic quadrants. If I have six schools that feed me, what's my conversation, because at some point I've already had a meeting with those high school principals. I have to bring those elementary principals into the conversation, because we're going to have an expectation of what STEM looks like here at our campus, and it could look totally different in the elementary level. After all, it starts with elementary first and at the

middle school level we must be consistent in reinforcing and reaffirming was taught previously to our students.

### **STEM High School Principals**

STEM high school principals reported that exposing students to STEM early sets the stage for students as they progress. The following quote articulates this finding. HSP 2 explained:

It is important for our students to become exposed to engineering, mathematics, and science and technology concepts when they're in elementary so that by the time they get to high school they already have a clearly established pathway in their mind. They will be able to say, okay, this is what I want to do; these are the kind of courses I know that I'm going to be taking. It's definitely about introducing the students but if we're able to get them involved and engaged in this STEM work at a much earlier pace starting from elementary school, and then we can start building greater opportunities for these students once they get to me. The truth is that they actually already know what's going on. We must build in that capacity.

### **Theme 5: Engaging and Empowering Girls is Important**

The next theme for Research Question 1 was *engaging and empowering girls is important*. It was mentioned 4 times in 3 interviews. This referred to the elementary, middle, and high school principals' perceptions that more women are entering the workforce in STEM related areas and encouraging and preparing female students is important with regards to technology implementation. Women are underrepresented in STEM fields in education and profession, with gender inequality particularly visible in disciplines such as mathematics, engineering, and computing (Roberts, 2014).

### **STEM Elementary School Principals**

STEM elementary school principals reported that engaging and empowering girls is important. The following quote articulated this finding. ESP 1 explained:

STEM is growing and I am a huge proponent in inspiring young ladies to pursue those areas. It is my goal to remind them that as a woman, you can be great in engineering, technology, and even in industrial arts. Tradition has changed and this will be a vital component of growth as STEM continues in the upcoming years.

### **STEM Middle School Principals**

STEM middle school principals reported that engaging and empowering girls is important. The following quote articulated this finding. MSP 1 explained:

I can definitely see that a lot of times girls kind of shy away from STEM and I know maybe not two years ago, we had a competition with just our girls. I had a girl's club and we did something called Shebot. They had to create their robots and put everything together and then they had a fashion show with their robots but the robots had to actually walk down the aisle. And so, just the eyes of those girls showed that we have a lot of them interested and a lot of times they don't want to take the courses because those courses are filled with boys. Some may feel intimidated but I do see this is rapidly changing.

### **STEM High School Principals**

STEM high school principals reported that engaging and empowering girls is important. The following quote articulated this finding. HSP 2 explained:

We've partnered with CITGO, and have received grants where we were able to provide female students with a summer STEM training opportunity. So, we're not only increasing

the number of young ladies that are going into STEM fields but we're also making a positive impact in our community where we're letting people know that our school is involved and engaged in STEM work. We also conduct a 'females in STEM' workshop day here.

## Research Question 2

Research Question 2 was what are the perceptions of principals regarding the sustainability of STEM programs within urban schools? There were five themes related to this research question. As reflected in Table 4.3, the themes were *partnering and collaborating to facilitate STEM increases sustainability*, *engaging stakeholders is a key to sustainability*, *principals' STEM vision is part of sustainability*, *resources are needed for sustainability*, and *leveraging teachers' expertise increases sustainability*. Appendix E shows the frequency with which the themes appeared across interviews and across the data for research question 2. The principals provided quotes that align with the specific themes and are represented by ES 1, MS 1, and HS 1.

Table 4.3

### *Themes for Research Question 2*

Themes
Partnering and collaborating to facilitate STEM increases sustainability
Engaging stakeholders is a key to sustainability
Principals' STEM vision is part of sustainability
Resources are needed for sustainability
Leveraging teachers' expertise increases sustainability

## **Theme 1: Partnering and Collaborating to Facilitate STEM Increases Sustainability**

The most frequently occurring theme for Research Question 2 was *partnering and collaborating to facilitate STEM increases sustainability*. This theme defined the principals' perceptions that partnering and collaborating with people and organizations to facilitate STEM resources increases sustainability. Partnering and collaborating to facilitate STEM increases sustainability was mentioned 15 times in 4 interviews. Collaborations and partnerships contribute to students' ability to solve problems they might face in the real-world (Kereluik, Mishra, Fahnoe, & Terry, 2013).

### **STEM Elementary School Principals**

STEM elementary school principals reported that partnering and collaborating to facilitate STEM increases sustainability. The following quote articulated this finding. ESP 1 explained:

I think we can do more to continue building partnerships. I'm being very transparent here.

I think that's something that we definitely have to do a better job of in the future to help our students and to strengthen our program.

### **STEM Middle School Principals**

STEM middle school principals reported that partnering and collaborating to facilitate STEM increases sustainability. The following quote articulated this finding. MSP 1 explained:

We are also very big with regards to engineering and mathematics, and so I am working to include more of those elements of STEM within our budget. I hope to provide more opportunities for partnering with organizations like Code Dot Org, and NASA. This is

especially for all of the organizations that provide actual opportunities for students at the middle school level.

### **STEM High School Principals**

STEM high school principals reported that partnering and collaborating to facilitate STEM increases sustainability. The following quote articulated this finding. HSP 1 explained:

We are going to continue with the partners that we have aligned with our program. This is very important when you talk about supporting and sustaining STEM on our campus.

Also, several alumni love to give back and help our students and they serve as partners as well.

### **Theme 2: Engaging Stakeholders is Vital to STEM Program Sustainability**

The next theme for Research Question 2 was *engaging stakeholders are vital to STEM program sustainability*. This theme referred to the elementary, middle, and high school principal's perception that engaging stakeholders, such as students, teachers, parents, community members, and businesses are vital to STEM program sustainability. Engaging stakeholders is a key to sustainability was mentioned 11 times in 6 interviews. Stakeholders are needed to help close achievement gaps, while increasing the STEM proficiency of all students (The University of Texas at Austin, 2018).

### **STEM Elementary School Principals**

STEM elementary school principals reported that *engaging stakeholders are vital to STEM program sustainability*. The following quote articulated this finding. ESP 2 explained:

What we've really been spending a lot of time on is really helping our parents understand the framework of our program and how does it work. We spend a lot of time on that.



### **STEM Middle School Principals**

STEM middle school principals reported that *engaging stakeholders are vital to STEM program sustainability*. The following quote articulated this finding. MSP 2 explained:

When I tell you, those parents were just blown away. It's amazing that many parents on a Friday showed up. Man, it was awesome! One of the things that the kids were doing with the project was celebrating black history month through poetry. The kids were creating their poems, but they're using the Chromebooks to recite the poems. So, if the kids started the poem, the Chromebook will continue the poem remotely as an exhibit of one of the happenings in black history. This was very cool how they implemented the project and the parents were surprised.

### **STEM High School Principals**

STEM high school principals reported that *engaging stakeholders are vital to STEM program sustainability*. The following quote articulated this finding. HSP 2 explained:

District support has been a good support. The support from the outside community has been a good support. So, if I could say both of them almost about hand in hand, district support and outside community support are necessary. We are working to increase parental support to bridge the gap between school and home for our students.

### **Theme 3: Principals' STEM Vision is Part of Sustainability**

The next theme for Research Question 2 was *principals' STEM vision is part of sustainability*. This theme refers to the elementary, middle, and high school principal's perception that having a vision for STEM as a principal is a part of program sustainability. Principals' STEM vision is part of sustainability was mentioned 6 times in 4 interviews.

Administrators' eagerness to delegate STEM leadership responsibilities with teachers helps to optimize school success and STEM program sustainability (Sublette, 2013).

### **STEM Elementary School Principals**

STEM elementary school principals reported that having a vision for STEM as a principal is a part of sustainability. The following quote articulated this finding. ESP 1 explained:

One of the biggest things is making sure that we actually have a vision. However, with our school being a STEM campus, my goal and my vision once again is to ensure that despite those challenges, in spite of circumstances, I actually provide avenues to actually replenish those opportunities that have become challenged. At the end of the day it's about the students and what's best for them. And so, I have to make sure the program is still going strong.

### **STEM Middle School Principals**

STEM middle school principals reported that having a vision for STEM as a principal is a part of sustainability. The following quote articulated this finding. MSP 2 explained:

When you think about a vision and trying to create a pathway for students, every aspect of your facility should support that vision. We kind of understand what a true STEM program looks like but now, what I'm extremely excited about is that we have become a part of the Magnet Schools of America, which allows for a lot of support. Of course, we registered for it but we are part of that organization now. So, I get weekly emails in terms of support, in terms of what other STEM programs look like across the country. Because of this my vision is not just to focus on [region] but I want our campus to become truly known for STEM internationally and globally.

## **STEM High School Principals**

STEM high school principals reported that having a vision for STEM as a principal is a part of sustainability. The following quote articulated this finding. HSP 2 explained:

Every stakeholder must be included in the school's vision With regards to STEM, each person plays a very important role in ensuring that students have what they need to aid them in success.

### **Theme 4: Resources Are Needed for Sustainability**

The next theme for Research Question 2 was *resources are needed for sustainability*. This theme refers to the elementary, middle, and high school principal's perception that resources are needed for STEM program sustainability. Resources are needed for sustainability was mentioned 5 times in 4 interviews. The primary focus of modern technology is to design the instructional experience with technology embedded, so that it supports desired outcomes and learner variability (Basham & Marino, 2013).

## **STEM Elementary School Principals**

STEM elementary school principals reported that resources are necessary for STEM program sustainability. The following quote articulated this finding. ESP 1 explained:

So, what we do is examine all of the components that we would need. That means that if its resources for the children, we make sure that we have those. If it's training for the teachers, we make sure that money is also incorporated in making those decisions also. Teachers have to be trained in order to be able to do those things that we want to do as far as STEM is concerned. So, resources are definitely a major component of STEM.

### **STEM Middle School Principals**

STEM middle school principals reported that resources are necessary for STEM program sustainability. The following quote articulated this finding. MSP 2 explained:

One of the things that we have is a dual program. Part of it is STEM and the other part is health and medical science. We must make sure that resources are provided for both entities. Going into the next school year, I want to incorporate drones. So, now we have started looking at the finances of what we have and what is projected. This will reveal totals which will allow us to plan for resources to implement that into our STEM program.

### **STEM High School Principals**

STEM high school principals reported that resources are necessary for STEM program sustainability. The following quote articulated this finding. HSP 1 explained:

My job as the facilitator and as the principal is to make sure that all the resources are there. I must make sure that our STEM program is competitive with the other STEM programs that we have in the area. I think that it could look different. I think that for some areas it may be a little bit more robust, and it could be because of the big word equity. Some areas don't have the same amount of resources that others do. Quite naturally, if you have a school with one thousand three hundred and you have a school with less than that, resource wise, per pupil, that's what you have to work with. But when you are proactive and you've secured grants and some funding you become competitive with the opportunity to be cutting edge.

## **Theme 5: Leveraging Teachers' Expertise Increases Sustainability**

The final theme for Research Question 2 was *leveraging teachers' expertise increases sustainability*. This theme defined the elementary, middle, and high school principal's perception that leveraging teachers' expertise in STEM increases program sustainability. Leveraging teachers' expertise increases sustainability was mentioned 3 times in 4 interviews. Building and sharpening STEM skills creates meaningful learning opportunities, provided context, and learning to be delivered using applied and collaborative techniques (Kennedy & Odell, 2014).

### **STEM Elementary School Principals**

STEM elementary school principals reported that that leveraging teachers' expertise in STEM increases program sustainability. The following quote articulated this finding. ESP 2 explained:

Well, I will call my teachers who really bring things to the table. So, I look at my teacher's strengths. Those math and science teachers and elective teachers who focus on coding and the context of engineering are individuals that become vital to the STEM curriculum. I also will review their certifications and look at their skill set to see how I can best utilize them through professional development.

### **STEM Middle School Principals**

STEM middle school principals reported that that leveraging teachers' expertise in STEM increases program sustainability. The following quote articulated this finding. MSP 2 explained:

Gateway to Technology is a great program that I've utilized with teachers in the past that kind of has a solid curriculum and just kind of again guiding our direction based on my campus curriculum. The core subject teachers that I have on my campus are valuable because I'm not going to receive more staff during this budget deficit. But looking at who

we have currently, what their skill sets are, what their certifications are, and what their passion makes the difference in providing the best for our students.

### **STEM High School Principals**

STEM high school principals reported that leveraging teachers' expertise in STEM increases program sustainability. The following quote articulated this finding. HSP 2 explained:

I feel like when the work of the program is in the hearts and the minds of the people, the hearts and the minds of the teachers, and the hearts and the minds of the parents and the kids, there is no force in this space that can take it away because it's ingrained in how we operate as a school. And so, once you build something so strong collectively with everyone else, they can't take the title. They can say you're not a STEAM Magnet but the work, and the planning, and how things are rolled out will still continue because it's so ingrained in the hearts and the minds of all the people that work at the campus level. All of my teachers attend professional development and my core subject teachers incorporate STEM and real-world examples into their lesson planning to provide students with a rich learning experience. I depend on them immensely with regards to sustaining STEAM at my campus.

### **Research Question 3**

Research Question 3 was how do urban principals develop knowledge about STEM education? The three themes related to this research question were summarized in this section. As reflected in Table 4.4, the themes were *education, professional development, and training; principals do their own research; and principals and staff receive coaching*. Appendix F shows the frequency with which the themes appeared across interviews and across the data for research question 3. The principals provided quotes that align with the specific themes and are

represented by ES 1, MS 1, and HS 1.

Table 4.4

*Themes for Research Question 3*

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Themes
Education, professional development, and training
Principals do their own research
Principals and staff receive coaching

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**Theme 1: Education, Professional Development, and Training**

The most frequently occurring theme for Research Question 3 was *education, professional development, and training*. This theme revealed how elementary, middle, and high school principals develop their knowledge about STEM education. Education, professional development, and training were mentioned 14 times in 6 interviews. STEM related professional development and training occasionally come with extra compensation as incentives for principals and experienced teachers to continue studies in their careers and remain in education (Office of Innovation & Improvement, 2016).

**STEM Elementary School Principals**

STEM elementary school principals reported that education, professional development, and training are how they develop their knowledge about STEM. The following quote articulated this finding. ESP 2 explained: “I think professional development is important. I think you have to make sure that you are providing opportunities to invest in your staff and to invest in yourself. Meaningful professional development is the key.”

### **STEM Middle School Principals**

STEM middle school principals reported that education, professional development, and training are how they develop their knowledge about STEM. The following quote articulated this finding. MSP 2 explained:

Stakeholders have to constantly be trained, because they always will know what the new thing is. You might not be able to afford the newest cutting edge resource, but at least you should learn what it is and what you can do to get it. You must stay in the loop. You must find opportunities to explore training. Education service centers like Region 4 conduct trainings continually throughout the year that help me to stay abreast of the new STEM trends.

### **STEM High School Principals**

STEM high school principals reported that education, professional development, and training are how they develop their knowledge about STEM. The following quote articulated this finding. HSP 2 explained:

My role as a STEM principal is to make sure that all of our content areas are aligned with high levels of rigor that can be attractive to students and to also make sure that our teachers are trained and up to date on some of the most things that are intriguing to our students. I try to make sure I can train my staff, and to do this I attend various conferences and trainings that infuse the concepts of STEM.

### **Theme 2: Principals Do Their Own Research**

The next theme for Research Question 3 was *principals do their own research*. This theme asserted that principals conduct their own research and observations to develop knowledge about STEM education. Principals do their own research was mentioned 6 times in 4 interviews.



There is a need to make the connections between the STEM subjects more transparent for administrators and educators (English, 2016).

### **STEM Elementary School Principals**

STEM elementary school principals in reported that they conducted their own research and observations to develop knowledge about STEM education. The following quote articulated this finding. ESP 2 explained:

I enjoy reading different articles about STEAM. STEAM is the thing right now. It's new and so a lot of people are trying to figure it out. And I'm talking about, how it can be used, how to implement it, and how they've done at their campus. So it's like the newest thing and there's a lot. I'm starting to see more articles about it. And so just really be well-read, so that I'm familiar with the research that's going on out there about STEAM and what some people are doing to implement it on their campus.

### **STEM Middle School Principals**

STEM middle school principals reported that they conducted their own research and observations to develop knowledge about STEM education. The following quote articulated this finding. MSP 2 explained:

One of the things that I was glad to be involved in this year was when my assistant principal brought project-based learning to the school. With some of the link learning money, we were able to get three Chromebook carts. So, you can see how those kids were using those Chromebooks to complete assignments. So, I try to watch what they're doing and then practice the concepts myself to stay on top of the trends. It is my goal to stay in the loop about the different things and how to use different processes.

## **STEM High School Principals**

STEM high school principals reported that they principals conducted their own research and observations to develop knowledge about STEM education. The following quote articulated this finding. HSP 2 explained:

As a school leader, I try to go as many places as I can to learn. I try to watch what my students are doing and support those that are participating in these projects, so that I can be a part of their learning. So, it's about making a collective effort working with my students, teachers, and parents to keep STEM as a focus so we keep our kids energized and excited about their learning. Also, having strong conversations with principals about what they're doing, to see how their staff has improved is a strategy. I ask a lot of questions, so I can get a lot of input. But just not being afraid to talk to other people about what's all going on.

## **Theme 3: Principals and Staff Receive Coaching**

The next theme for Research Question 3 was *principals and staff receives coaching*. This theme supported the elementary, middle, and high school principals' responses that they are receiving coaching to develop knowledge about STEM education. Principals and staff receive coaching was mentioned 5 times in 4 interviews. Various types of coaching increases implementation rates of professional development within the school compared to workshops that do not have any follow-up (Aguilar, 2013).

## **STEM Elementary School Principals**

STEM elementary school principals reported that they were receiving coaching to develop knowledge about STEM education. The following quote articulated this finding. ESP 2 explained:

I enjoy reading different articles about STEAM. STEAM is the thing right now. It's new and so a lot of people are trying to figure it out. I must continue to research to ensure that we are implementing STEAM the right way on our campus.

### **STEM Middle School Principals**

STEM middle school principals reported that they were receiving coaching to develop knowledge about STEM education. The following quote articulated this finding. MSP 1 explained:

If your staff is learning about STEM then you should also be in the meeting because you want to be a student and you want to be a teacher learning just like them. So whenever my staff is learning about STEM, I'm in there too because I'm still learning. I want to be able to support them with what they need. This is a priority.

### **STEM High School Principals**

STEM high school principals reported that they were receiving coaching to develop knowledge about STEM education. The following quote articulated this finding. HSP 2 explained:

We are collaborating with Educate Texas and they provide coaching for us. They actually send technical support to our campus and are able to help us network with other schools and colleagues. So, want to make sure we're implementing professional development with the colleagues that are also involved in this work because that's where you're going to get the bang for your buck as far as practitioners in the STEM field.

### **Research Question 4**

Research Question 4 was what are the perceptions of principals regarding barriers to learning for STEM students? The six primary themes related to this research question were

summarized in this section. As reflected in Table 8, the primary themes were *lack of funding is a barrier, lack of adequate STEM staff is a barrier, lack of resources can be a barrier, not leveraging technology most effectively can be a barrier, location of STEM programming can be a barrier, student's lack of skills can be a barrier*. Appendix G shows the frequency with which the themes appeared across interviews and across the data for research question 4. The principals provided quotes that align with the specific themes and are represented by ES 1, MS 1, and HS 1.

Table 4.5

*Themes for Research Question 4*

Themes
Lack of funding is a barrier
Lack of adequate STEM staff is a barrier
Lack of resources can be a barrier
Not leveraging technology most effectively can be a barrier
Location of STEM programming can be a barrier
Students lack of skills can be a barrier

**Theme 1: Lack of Funding is a Barrier**

The most frequently occurring theme for Research Question 4 was *lack of funding is a barrier*. This theme was defined by elementary, middle, and high school principals as a barrier to learning for STEM students. Lack of funding was mentioned 10 times in 5 interviews. The department that is responsible for coordinating federal STEM programs has made it much harder to acquire STEM funding. Lack of STEM access is a critical equity issue in education (Sawchuk, 2018). Ejiwale (2013) indicated that many schools are not provided with the needed facility

structure, tools, equipment, or required instructional media to suitably support STEM.

### **STEM Elementary School Principals**

STEM elementary school principals reported that lack of funding is a barrier to learning for STEM students. The following quote articulated this finding. ESP 2 explained:

The biggest barrier is funding, because even the smallest schools that have good programs must find a way to secure the funding for resources. You must have somebody that believes in the program. If they believe in the kids, they find a way to get it done. Also, because of the effects of Hurricane Harvey the resources that we have had previously, may not be accessible. Many of the resources were either damaged or discontinued due to the budget challenges.

### **STEM Middle School Principals**

STEM middle school principals reported that lack of funding is a barrier to learning for STEM students. The following quote articulated this finding. MSP 1 explained:

Because of the budget shortfalls, we just don't have extra funding and it requires us to be creative, utilize some of the resources that we currently have, and reach into the minds of our community members so that they can see that this is our vision, this is what our purpose is, how can you support us? And so, to be honest that's where I am at this point. I know I received a grant today for \$1800 and that's great and I'm happy for that but \$1800 won't cover everything. And so it's a struggle right now.

### **STEM High School Principals**

STEM high school principals reported that lack of funding is a barrier to learning for STEM students. The following quote articulated this finding. HSP 1 explained:

I like the idea that HISD offers so much variety to students everywhere, but as a principal when you look at your funding you really compete for students and make sure that your campus is attractive, and you can meet your enrollment projections.

## **Theme 2: Lack of Adequate STEM Staff is a Barrier**

The next theme for Research Question 4 was *lack of adequate STEM staff is a barrier*. Elementary, middle, and high school principals explained that the lack of adequate STEM staff could be a barrier to learning for STEM students. Lack of adequate STEM staff was mentioned 8 times in 5 interviews. There is a shortage in supply of qualified STEM teachers, a lack of investment in teachers' professional development, and a lack of research collaboration across STEM fields (Ejiwale, 2013).

### **STEM Elementary School Principals**

STEM elementary school principals reported that the lack of adequate STEM staff is a barrier to learning for STEM students. The following quote articulated this finding. ESP 2 explained:

As a principal, I am also faced with ensuring that I have the funds to cover the staff applicable for the positions at our campus. Since we are a STEM campus, I have to make difficult decisions of who stays and what can wait. So, if we don't have the funding for the staff, this can definitely be seen as a potential barrier for students.

### **STEM Middle School Principals**

STEM middle school principals reported that the lack of adequate STEM staff is a barrier to learning for STEM students. The following quote articulated this finding. MSP 2 explained:

The way our STEM program was set up was pretty much under the magnet program, and so kids from across the city can come to our campus and be a part of our STEM program.

So that requires recruitment, and that requires making sure offerings are solid. The magnet coordinator and investment in that particular position has been extremely instrumental and that person has been my backbone, my right hand, and my community liaison. Unfortunately, that position has been removed from the campus level but we do have a school choice office. Hopefully they will be able to provide similar assistance to our campus regarding the needs of our STEM students.

### **STEM High School Principals**

STEM high school principals reported that the lack of adequate STEM staff is a barrier to learning for STEM students. The following quote articulated this finding. HSP 2 explained:

I need a learned amount of personnel, because we need to cover the deficits and increase the exposure. It takes a lot of people and as the state increases their expectations for data results. Then we have to have more people willing to work with us to help meet state expectations. So, I would really like to see a lot of money going into putting enough teachers in critical shortage areas or in critical testing areas to support students in underserved communities because that's what we really need. We need more workers that can handle the work because our students have emotional needs that are negatively impacting their academic abilities because they can't get past these social barriers that they are experiencing. So, I would definitely like to see an emphasis put on that at the high school level.

### **Theme 3: Lack of Resources Can be a Barrier**

The next theme for Research Question 4 was *lack of resources can be a barrier*. Elementary, middle, and high school principals explained that a lack of resources can be a barrier to learning for STEM students. The lack of resources was mentioned 4 times in 3 interviews.

Predominantly impoverished neighborhoods do not have the resources due to the racial, socioeconomic achievement gap in math and science (Wolfe, 2018).

### **STEM Elementary School Principals**

STEM elementary school principals reported that the lack of resources is a barrier to learning for STEM students. The following quote articulated this finding. ESP 1 explained:

With the budget challenges, we have witnessed many of our resources being cut or sliced in half. We definitely could use more technology and STEM related resources on our campus. It is my understanding that we must grow with the times and become change agents for our students.

### **STEM Middle School Principals**

STEM middle school principals reported that the lack of resources is a barrier to learning for STEM students. The following quote articulated this finding. MSP 1 explained:

We're strong but we're missing certain pieces of technology, having more interactive classrooms, and having more robotics equipment. I really have a vision of maybe developing an underwater robotics program that requires kits and robots. Of course I'm concerned for our future, as I do want to see our kids exposed to more than just the computer.

### **STEM High School Principals**

STEM high school principals reported that the lack of resources is a barrier to learning for STEM students. The following quote articulated this finding. HSP 1 explained:

So, I think we're in a good place to build a solid STEM program but STEM is constantly evolving and there is room for more resources and funding. We must provide resources for our students against all odds.



#### **Theme 4: Not Leveraging Technology Most Effectively Can be a Barrier**

The next theme for Research Question 4 was *not leveraging technology most effectively is a barrier*. Elementary, middle, and high school principal's explained that not knowing how to leverage technology most effectively can be a barrier to learning for STEM students. Not leveraging technology most effectively was mentioned 3 times in 3 interviews. Unfortunately, some teachers believe technology does not allow students to think through the learning process (Heick, 2016).

##### **STEM Elementary School Principals**

STEM elementary school principals reported that not leveraging technology most effectively can be a barrier for STEM students. The following quote articulated this finding. ESP 1 explained:

I tell my teachers often that you're going to have to learn how to be able to incorporate the technology components into the classroom. You can't just sit there and talk to them all that time. They're not going to listen. Research says, they only going to listen for fifteen minutes and that's it.

##### **STEM Middle School Principals**

STEM middle school principals reported that the not leveraging technology most effectively can be a barrier for STEM students. The following quote articulated this finding. MSP 1 explained:

Integrating technology into all subject areas is extremely important with regards to instruction. All staff members at a STEM campus should be able to identify the technological components that help to reinforce the student's learning experience. If there

is not a technology component embedded within the lesson being taught, then the student is being done a huge disservice.

### **STEM High School Principals**

STEM high school principals reported that the not leveraging technology most effectively can be a barrier for STEM students. The following quote articulated this finding. HSP 2 explained:

So, as we are purchase technology and make provisions for virtual resources, we face a challenge. The question now becomes, how do we use technology in a more efficient fashion to help students accelerate their instruction in schools?

### **Theme 5: Location of STEM Programming Can be a Barrier**

The next theme for Research Question 4 was *location of STEM programming can be a barrier*. Elementary, middle, and high school principals explained that the location of STEM programming can be a barrier for student access. The geographic location of STEM programming can be a barrier was mentioned 3 times in 4 interviews. There are opportunity gaps for students in urban communities that have gone overlooked for decades and have had negative impacts on students and teachers in education (Buffington, 2017).

### **STEM Elementary School Principals**

STEM elementary school principals reported that the location of STEM programming can be a barrier for student access. The following quote articulated this finding. ESP 2 explained:

So, as we are purchase technology and make provisions for virtual resources, we face a challenge. The question now becomes, how do we use technology in a more efficient fashion to help students accelerate their instruction in schools? How do we make our

STEM program the best in our area? How do we make this the go-to elementary campus exemplar for STEM concepts?

### **STEM Middle School Principals**

STEM middle school principals reported that the location of STEM programming can be a barrier for student access. The following quote articulates this finding. MSP 2 explained:

So, you have a parent that lives in Third Ward and the program is at Fondren Middle School. That's a long way to go. The bus commutes over there, but right now that's the only option that they have. If you don't have another program, like you say, that's sustainable on this side of town, this becomes a challenge.

### **STEM High School Principals**

STEM high school principals reported that the location of STEM programming can be a barrier for student access. The following quote articulated this finding. HSP 1 explained:

There's not an aviation program in HISD that I know of. So therefore, those students are probably traveling from all over the place to attend an aviation program. Nobody else seems to have that program other than businesses like NASA and Lockheed Martin. Location is everything and accessibility to these locations matters.

### **Theme 6: Students' Lack of Skills Can be a Barrier**

The next theme for Research Question 4 was *students' lack of skills can be a barrier*. Elementary, middle, and high school principals explained that a lack of skills can be a barrier to learning for STEM students. Students' lack of skills can be a barrier was mentioned 3 times in 5 interviews. Students will substantially fail if they are not taught how to think critically and solve problems in STEM (Carnegie Science Center, 2014).

### **STEM Elementary School Principals**

STEM elementary school principals reported that STEM student's lack of skills as being a barrier to learning. The following quote articulated this finding. ESP 1 explained: If some of the students are not able to be exposed to a lot of the real-world experiences to keep them interested in the areas of STEM, then I think that this is huge barrier.

### **STEM Middle School Principals**

STEM middle school principals reported that STEM student's lack of skills as being a barrier to learning. The following quote articulated this finding. MSP 1 explained:

Teachers and staff must reinforce the learning to affirm that students understand how STEM relates to the career goals that they have. Students must be able to make these connections or else the reasoning for STEM can become lost and the learning is stagnant.

### **STEM High School Principals**

STEM high school principals reported that STEM student's lack of skills as being a barrier to learning. The following quote articulated this finding. HSP 1 explained:

I make sure that we provide our students with the opportunity to connect with businesses in the surrounding [region]. Through this, students have the chance to seek employment and internships that is aligned to their STEM areas of expertise. Without this component, we are doing our students a disservice and hindering their skills and growth.

### **Summary**

The purpose of this qualitative study was to describe the perceptions of urban district principals regarding technology implementation and identify recommendations for the sustainability of STEM programs within this Texas Urban School District. This chapter included a summary of the study findings, the data analytic approach, and tables revealing the identified

themes. In addition, the number of interviewees that mentioned a specific theme with quotes was provided. All of these elements served to organize the data to support the perceptions of the elementary, middle, and high school principals. STEM program sustainability and technology implementation can be enhanced through businesses and partnerships that consistently provide STEM resources, career pathway opportunities, and higher education contacts (Project Lead the Way, Inc., 2018). These resources lessen the barriers to learning for STEM students in underprivileged areas as they pursue professional opportunities. Continuous professional development and training is pertinent in STEM education, as the workforce grows and as technology evolves (NAF, 2017). Chapter 5 will provide an interpretation of the findings, recommendations for action, and recommendations for further research.

## CHAPTER FIVE

### DISCUSSION

Upon beginning this study three years ago the researcher served as an Academic Trainer who trained principals across the elementary, middle and high school levels. It was during that time that the urban district was beginning the foundational stages a significant budget shortfall of 107 million dollars. Historically, the district had experienced budget challenges but none would prove to be as massive as the 2016-17 school year. Due to the budget shortfalls, the existence of STEM education programs within this Texas Urban School District became threatened and principals were directed to review their respective budgets to determine where potential cuts could be allocated. Many of these cuts ultimately affected the reduction of school electives and the STEM programs with a reduction in resources and staff members qualified to teach in STEM-specific areas.

This qualitative study allowed the researcher to explore and describe the perceptions of urban district principals regarding technology implementation and identify recommendations for the sustainability of STEM programs. Four guiding questions led this work:

1. What are the perceptions of principals regarding the implementation of technology within urban schools?
2. What are the perceptions of principals regarding the sustainability of STEM programs within urban schools?
3. How do urban principals develop knowledge about STEM education?
4. What are the perceptions of principals regarding barriers to learning for STEM students?

This research study consisted of six STEM principals, with two of each deriving from the elementary, middle, and high school levels. Upon receiving approval from the Texas Urban School District's Office of Research and Accountability, the Office of School Leadership helped to facilitate the Informational Letter in Appendix A. The letter served as the invitation to ten STEM campus principals. Six STEM principals responded to the invitations and the semi-structured interviews were conducted from March, 2018 to April, 2018.

The study's findings represent the principals' perceptions regarding technology implementation and STEM program sustainability. They also explain how principals expand their knowledge about STEM education and the factors that are perceived as barriers to learning for STEM students. Merriam (2009) emphasizes the importance of examining and interpreting the findings in relation to relevant theories and current literature. The interpretations are based on principals' perceptions and provide a deeper understanding of their experience. This chapter provides the interpretation of the findings, explores the implications of these findings, and ends with recommendations for further studies.

### **Interpretation of Findings**

During the qualitative analysis, the researcher uncovered nineteen major themes from the elementary, middle, and high school principals' responses. The themes were organized into four areas, with each area focusing on one of the four research questions. Prior to responding to the interview questions, each of the principals completed a consent form, and provided a brief synopsis of their background experience in education and experience on a STEM campus. Second, the principals explained the vision for their campuses and how this particular study aligned to their beliefs regarding technology implementation and STEM program sustainability.

As the elementary, middle, and high school, principal interviews occurred, the researcher was able to identify the theme commonalities across the 3 cases.

### **Research Question 1**

Research Question 1 asked, what are the perceptions of principals regarding the implementation of technology within urban schools? The most frequently occurring theme for Research Question 1 was *STEM skills and technology for students are imperative*. Based upon the qualitative data analysis in Chapter 4 and to answer Research Question 1, the elementary, middle, and high school principals perceived technology implementation and STEM skills to be imperative in urban schools regarding preparation for the workforce and for future skill development. The principals also explained that students must have hands-on STEM experience, that more STEM technology is needed, that exposing students to STEM early sets the stage, and that engaging and empowering girls in STEM is important.

### **Theme 1: STEM Skills and Technology for Students Are Imperative**

STEM education is the pillar for future occupational endeavors (Tata Consultancy Services, 2013). STEM skills and technology give students knowledge, attitudes, and skills to identify questions and problems in real world situations. The principals explained that students need the ability to explore the natural world and draw evidence-based conclusions about STEM-related issues (Bybee, 2013). Students further understand the characteristic features of STEM disciplines as forms of human knowledge, inquiry, and design. There is exposure to an awareness of how STEM disciplines shape our material, intellectual, and cultural environments. STEM education matures students to have the eagerness to be involved in problem solving and with the concepts of STEM education as a constructive, concerned, and reflective citizen (Bybee, 2013).



Collaboration and leadership work in hand with initiative and entrepreneurialism. Curiosity and imagination require agility and adaptability (Deangelis, 2014). As an alignment with Chapter 2, all of these tenets are imperative regarding the infusion of technology into today's everchanging society.

### **Theme 2: Students Must Have Hands-on STEM Experience**

Hands-on STEM engagement activities are likely to foster or maintain positive STEM dispositions at the middle school and high school levels (Christensen, Knezek, & Tyler-Wood, 2015). These experiences are more open-ended. Students are allowed to have more uncertainty. The uncertainty encourages students to engage in activities and increases their level of commitment (Sahin, Ayar, & Adiguzel, 2013). Hands-on STEM experience provides opportunities for students to plan, design, build, evaluate, and rebuild (Christensen, Knezek, & Tyler-Wood, 2015). The elementary, middle, and high school principals described the elements as vital components to STEM and within curricula development. The elementary, middle and high school principals interviewed for this study all expressed that their STEM programs consisted of at least one of the entities towards providing their students with the opportunity grow in the STEM disciplines.

### **Theme 3: More STEM Technology is Needed**

With the understanding that technology is shifting the expectations in all areas within today's workforce, and as the workplace continues to evolve, career seekers require the critical-thinking and problem-solving skills that STEM education fosters (Elgart, 2015). Students should be equipped to think critically, so that they have the opportunity to become the innovators, educators, researchers, and leaders who can answer the difficulties facing our world, both today and tomorrow. However, as of now, not enough of our youth have access to quality STEM

learning opportunities, and too few students see these disciplines as springboards for their careers (U.S. Department of Education, 2015). Today's youth must engage in an array of technological and educational experiences that enable them to develop the full range of skills needed to adapt to the jobs of tomorrow and succeed in the STEM economy (Flynn, 2017).

A key tenant in STEM technology for STEM education is robotics (Khanlari, 2013). Robotics influences many educational aspects and has an enormous impact on students' abilities and skills (Khanlari, 2013). Robotics, learning analytics, mobile learning, and gaming are all becoming vital components in STEM, as expressed earlier in the review of literature.

#### **Theme 4: Exposing Students to STEM Early Sets the Stage**

One approach to promoting relevance and engagement is through STEM subject integration in years of age seven to ten (Bybee, 2013). The elementary, middle, and high school principals of this study asserted that students must experience the foundational stages of STEM as the building blocks into the career pathways of these areas. STEM education should be presented as early as kindergarten to heighten children's enthusiasm, interest, and exposure. Waiting until children reach college to motivate them to participate in STEM will not boost their confidence level. A robust K-6 foundation is required to make STEM learning more comfortable for children (Born, 2018). This early foundation is required to ensure more students pursue STEM majors and minors in college. Without a strong foundation, students may experience failure or disinterest (Marak, 2017). The principals of this study definitely agreed that STEM curriculum should start at the elementary levels and should be supported through the middle school and high school years. The elementary, middle, and high school principals also explained that exposing students can be motivated and supported to learn about colleges and businesses that align with their career goals (Chiu, Price, & Ovrachim, 2015).

## **Theme 5: Engaging and Empowering Girls in STEM is Important**

Women are underrepresented in STEM fields in education and profession, with gender inequality particularly visible in disciplines such as mathematics, engineering, and computing (Roberts, 2014). The causes are deeply ingrained and intertwined with historical and cultural norms (Young, Young, & Paufler, 2017). Inadequate support of girls in mathematics is particularly troubling, as this is a gateway discipline to other fields (Tan, Calabrese Barton, Kang, & O'Neill, 2013). It is not only beneficial to have studied intermediate or advanced level mathematics at secondary school, but it is a requisite to advanced study in STEM disciplines, such as engineering and computing.

To improve female involvement in both study and employment within mathematics and other STEM fields, influences are recommended. Influences that have the potential to engage and empower girls in the STEM fields are government-led measures, financial incentives, direct support programs, school-based measures, industry or employer-led measures, and community development (Roberts, 2014). Elementary Principal 1 and Middle School Principal 2 in this research study both expressed their stance of motivating more female students to pursue career pathways in STEM-related disciplines. Appendix H provides an infographic that represents the relative number of women in STEM careers (Jacksonville University, 2017).

### **Research Question 2**

Research Question 2 was what are the perceptions of principals regarding the sustainability of STEM programs within urban schools? The most frequently occurring theme for Research Question 2 was *partnering and collaborating to facilitate STEM increases sustainability in urban schools*. Based upon the qualitative data analysis in Chapter 4 and as an answer to Research Question 2, the elementary, middle, and high school principals perceived that

partnering and collaborating with people and organizations to facilitate STEM resources increases sustainability in urban schools. The principals also explained that engaging stakeholders is a key to sustainability, principals' STEM vision is required for sustainability, resources are needed for sustainability, and leveraging teachers' expertise increases sustainability.

### **Theme 1: Partnering and Collaborating to Facilitate STEM Increases Sustainability**

Corporations, community groups, and educational institutions all face a significant challenge and opportunity in motivating and developing the next generation of STEM workers (Davis & Veenstra, 2014). As businesses partner or collaborate with schools to facilitate STEM learning, sustainability is increased through showcasing the future opportunities in STEM-related careers for students. This simple concept generates genuine excitement in STEM subjects within and outside of the classroom for today's generation. Companies contribute to STEM's future workforce by providing mentorship, especially by encouraging women and minorities to embrace STEM development (Tata Consultancy Services, 2013). All principals of this research study described their plans for collaborating and partnering with businesses, community members, and even parents towards enhancing the support for STEM at their campuses. In lieu of the continuous budget challenges described in this study's problem statement, principals believe that increasing partnerships at their campuses will ultimately increase STEM program sustainability and that this strategy offers a stronger support system for all stakeholders.

### **Theme 2: Engaging Stakeholders is a Key to Sustainability**

STEM stakeholders include teachers, principals, community members, district administrators, university researchers, philanthropists, business and civic leaders (The University of Texas At Austin, 2018). Stakeholders are needed to help close achievement gaps, while

increasing the STEM proficiency of all students (The University of Texas At Austin, 2018). Leaders have to advance STEM education to create a pipeline they can use to renew their companies with innovative ideas continually. Stakeholders have to change their perception by educating students, teachers, career counselors, and parents about the varied opportunities that may require STEM skills. It is necessary to develop and implement a concerted strategy for finding intellectual capital and investing in the education of young people so that they have a pipeline of capable workers to fill these vital knowledge-based jobs (Tata Consultancy Services, 2013). As an alignment to Chapter 2, it is critical for the principals to ensure that the school culture is one where educators are supported to teach in 21<sup>st</sup>-century ways. Twenty-first century teaching methodologies allow STEM students to develop the skills that they need now, not those they needed 30 years ago (Criterion Conferences, 2016).

### **Theme 3: Principals' STEM Vision is Part of Sustainability**

In order to guarantee that STEM education is an expectation for all students and to improve it in the United States, principals must include all stakeholders as a component of the STEM vision (Capraro & Lewis, 2013). Teachers must be presented with the right professional development opportunities that will allow them to lead all their students toward acquiring STEM literacy (Capraro, & Lewis, 2013). Administrators' eagerness to delegate STEM leadership responsibilities with teachers helps to optimize school success and STEM program sustainability (Sublette, 2013).

Principals must provide opportunities to connect STEM educators and their students with the broader STEM community and workforce (Carraway, Rectanus, & Rectanus, 2015). Students need interdisciplinary, multicultural, and multi-perspective viewpoints to demonstrate how STEM transcends national boundaries, thus providing them with a global perspective (Kennedy

& Odell, 2014). Effective teacher leadership combines form with function to create transformative change in schools. These efforts allow STEM education to be sustained. As previously stated in Chapter 2, without a clearly defined vision that is inclusive of all stakeholders, STEM campuses face the possibility of being ineffective and unsuccessful (Sheninger, 2014). The U.S. Department of Education (2008) further supported that: staff development and training, community partnerships, program recognition, school board support, funding sources are all elements of STEM program sustainability.

#### **Theme 4: Resources are Needed for Sustainability**

The overarching goal of STEM education in U.S. schools is to prepare all students for post-secondary study and the 21st-century workforce (Kennedy & Odell, 2014). Appropriate technologies such as modeling, simulation, and distance learning are needed to enhance STEM education learning experiences (Basham & Marino, 2013). Modern technology engages learners and provides multiple ways for students to gain information and express their understanding. The primary focus of this critical element is to design the instructional experience with modern technology so that it supports both desired outcomes and learner variability (Basham & Marino, 2013). The high school principals of this study expressed that they had various resources at their campuses but all of the principals stated that they could use more and that the technology could definitely be updated.

#### **Theme 5: Leveraging Teachers' Expertise Increases Sustainability**

Experienced STEM principals should recognize the inherent opportunities to strengthen and support the teaching of STEM education, and where possible, to integrate STEM applications into the curriculum (Kennedy & Odell, 2014). STEM education requires implementing instructional strategies that integrate the teaching of science, technology,

engineering and math in a way that challenges students to be innovative. STEM teachers use problem-based and project-based learning with a set of specific learning outcomes to support instruction. Leveraging those STEM skills creates meaningful learning opportunities, provided context, and learning to be delivered using applied and collaborative techniques (Kennedy & Odell, 2014). Students are required to explain their understanding in an environment that models real-world contexts for learning and work.

Students are offered interdisciplinary, multicultural, and multi-perspective viewpoints to demonstrate how STEM transcends national boundaries providing students a global perspective that links students with a broader STEM community and workforce (Kennedy & Odell, 2014). Traditional teaching and learning methods are confronted in a STEM environment. Sustaining the work of expert teachers in full-time roles requires school leaders to consider what the roles are established to leverage fully. STEM leaders must regularly find ways to increase the capacity of the STEM teacher leader as they fill these roles. Leveraging the trust and leadership of the STEM teacher's expertise promotes overall team performance that grows into lasting STEM sustainability (Tytler et al., 2015).

### **Research Question 3**

Research Question 3 was how do urban principals develop knowledge about STEM education? The most frequently occurring theme for Research Question 3 was *education, professional development, and training*. Based upon the qualitative data analysis in Chapter 4 and as an answer to Research Question 3, the elementary, middle, and high school principals revealed that they develop their knowledge about STEM education through education initiatives, professional development, and training. The principals also explained that they do their own research, and that they and their staff receive coaching.

## **Theme 1: Education, Professional Development, and Training**

Being a successful STEM leader is a never-ending process of improvement (Blackley & Howell, 2015). There are financial costs and work commitments to retraining teachers and adapting pre-service teacher education programs to prepare for the implementation of integrated STEM education (Blackley & Howell, 2015). STEM related professional development and training occasionally come with extra compensation as incentives for principals and experienced teachers to continue studies in their careers and remain in education (Office of Innovation & Improvement, 2016).

High-quality STEM education programs provide stakeholders with opportunities to collaborate with one another in unified efforts aimed at integrating the STEM concepts into one cohesive means of teaching and learning (Blackley & Howell, 2015). It is when this objective is achieved that students gain access to meaningful curricular opportunities and the promoting of critical thinking skills that can be applied to their academic and everyday lives (Kennedy & Odell, 2014). As a vital component to STEM programs, the elementary, middle, and high school principals all expressed that professional development and training is conducted regularly through the school year at their campuses.

## **Theme 2: Principals Do Their Own Research**

There is a need to make the connections between the STEM subjects more transparent for administrators and educators (English, 2016). Amongst the calls for a more significant concentration on STEM education in schools the attention is undoubtedly drawn to the quality of teaching (Anderson, 2016). There are appropriate means of supporting the teaching profession, so that more young people are engaged and interested in STEM subjects (Anderson, 2016). Principals are required to develop a professional learning community for improving



STEM teaching in schools. These standards are expressed in Chapter 2, Review of Literature under the ISTE Administrator Standards Digital Leadership Culture (International Society in Technology Education, 2015).

Integrating the STEM subjects forges connections and highlights real-world applications (Vasquez, Sneider & Comer, 2013). To adopt a STEM curriculum perspective, principals require horizontal expertise, and they need to ‘boundary cross or step into unfamiliar domains’ (Clarke, 2014). Team building and effective whole-school planning are critical components. Schools must embrace a wide variety of approaches to implementing STEM education. Choices are usually based on available personnel, teacher interest, and resources. At times, school structures can be challenges to innovative practices (Anderson, 2016).

Principals focusing on student engagement, educators from institutions of higher education, and K-12 schools can work together to develop pedagogical models that provide rigorous, well-rounded education and outstanding STEM instruction (Anderson, 2016). STEM campuses give witness that goal-directed practice combined with useful feedback enhances the quality of learning. As part of students becoming self-directed learners, they must learn to monitor and adjust their learning approaches (NSW Department of Education, 2017).

### **Theme 3: Principals and Staff Receive Coaching**

Coaching is a needed element of a professional development program (Aguilar, 2013). Coaching builds determination, skill, knowledge, and capacity because it can extend the rigor within professional development (Aguilar, 2013). Coaches touch on the intellect, behaviors, practices, beliefs, values, and feelings of an educator or leader. Coaching alone creates a relationship in which the teacher feels cared for and is therefore, able to access and implement

new knowledge. A coach has space where healing can take place and where resilient, joyful communities are built (Aguilar, 2013).

A STEM coach translates scientific inquiry into actual classroom instruction that is a demanding task (Aguilar, 2013). It requires both discipline-based inquiry, content knowledge, and skills in inquiry teaching. The STEM coach trains stakeholders to develop and implement a guided inquiry lesson that used the context to teach a science, technology, engineering or math concept. Various types of coaching increases implementation rates of professional development within the school compared to workshops that do not have any follow-up (Aguilar, 2013). STEM principals utilize coaching and partnerships to keep their campus abreast of the latest trends in STEM.

#### **Research Question 4**

Research Question 4 was what are the perceptions of principals regarding barriers to learning for STEM students? The most frequently occurring theme for Research Question 4 was *lack of funding is a barrier*. Based upon the data analysis in Chapter 4, and as an answer to Research Question 4, the elementary, middle, and high school principals' perceived the lack of funding as to be a barrier to learning for STEM students. The principals also explained that lack of adequate STEM staff is a barrier, lack of resources can be a barrier, not leveraging technology most effectively can be a barrier, location of STEM programming can be a barrier, and students' lack of skills can be a barrier.

#### **Theme 1: Lack of Funding as a Barrier**

All of the principals of this study expressed the barrier of lack of funding as the main challenge that faces their campus budget. This barrier also speaks to the problem statement described in Chapter 1. Education in the STEM fields of science, technology, engineering, and

mathematics continues to be a priority for federal legislators, agencies, and even President Donald Trump (Sawchuk, 2018). However, the department that is responsible for coordinating federal STEM programs has made it much harder to acquire STEM funding. Lack of STEM access is a critical equity issue in education (Sawchuk, 2018). This is true for students in urban and rural communities (Sawchuk, 2018). These locations are where opportunities for high-level math and science courses is often out of reach.

This problem disproportionately affects underserved communities lacking access to funding and resources for STEM education. The households in these underserved communities often have limited access to necessary academic resources, and many only have one parent in the home (Kimrey, 2017). The impact of students living in STEM “dry spots” will not only be reflected in those students' high school and college completion statistics, but it will later influence on the country's technological superiority, its economy, and national security (Randazzo, 2017). When it comes to low-income school districts that are all too often underfunded, STEM provides an opportunity to escape the cycle of poverty (Donaldson, 2017).

Ejiwale (2013) indicates that many schools are not provided with the needed facility structure, tools, equipment, or required instructional media to suitably support STEM programming. Money is not designated to all subjects and disciplines equally. At present, more money is used to support school initiatives and subjects that are deemed as more or most “important.” Education is an expensive endeavor. In the 2010-2011 school year, an average of over twelve-thousand dollars in public funds was spent per student in the United States (U.S. Department of Education, 2013). The current education system leaders are not providing adequate resources to offer quality STEM education for all students.

Additionally, the shortage of investment in the professional development of teachers for stimulating their knowledge base has been attributed to inadequate student achievement. As excited teaching excites students, new teachers need professional internships for training following completion of a degree (Ejiwale, 2013).

### **Theme 2: Lack of Adequate STEM Staff as a Barrier**

Recent graduates do not have the innovative spirit and drive to advance STEM-related learning (Land, 2013). Teacher education programs should provide pre-service STEM teachers with more opportunities to practice for the profession. A program that emphasizes teaching practice through integrated technological knowledge may better prepare pre-service STEM teachers for the profession (Corlu, Capraro, & Capraro, 2014). Excessive emphasis on theory in the coursework through subject-area or pedagogy courses widens the gap between the realities of the K-12 level teaching and teacher education at the higher education level.

Teacher education programs should graduate teachers who are experts in content and pedagogy rather than graduating content or pedagogy experts who are eligible to become teachers (Corlu, Capraro, & Capraro, 2014). Teacher placement is one of the best means to ease the integration of company-sponsored programs in school curricula, helping policymakers meet the challenge of a lack of resources in schools and expand their knowledge about STEM subjects (STEM Alliance, 2017).

Teachers who have been STEM professionals before becoming teachers bring valuable work and life experience skills to the classroom. Professionals who have been successful in STEM areas outside of the teaching field, such as mathematicians, technologists, engineers or scientists, have current expertise and experience in the discipline. These qualified individuals enable students to adequately demonstrate the link between content knowledge in math and

science, and its diverse uses in real workplaces. They can act as role models and can engage students by helping them to develop a broader understanding and interest in STEM areas and opportunities. Science and math become more exciting and relevant to students when they can see the connection between fundamental theories and its functional application. Bringing the field and career experience into the classroom sparks passion and interest (Varadharajan, 2017).

### **Theme 3: Lack of Resources as a Barrier**

As described by the elementary, middle, and high school principals, this theme serves as a commonality to resources being necessary for STEM program sustainability. The 2019 Trump Administration budget is making STEM education a priority (Wolfe, 2018). Currently, the STEM workforce is no more diverse as it was back in 2001 (Kimrey, 2017). There is a lack of STEM educational opportunities in urban environments (Wolfe, 2018). Predominantly impoverished neighborhoods do not have the resources need to narrow the racial, socioeconomic achievement gap in math and science (Wolfe, 2018). Underserved communities without access to funding and resources for STEM education allows the pattern of the STEM professional field increasing positions by Caucasian and Asian professionals, predominantly men, to continue.

Hardworking district leaders and teachers of underserved communities are willing to secure the resources and set up to expand academic options for students, but these supports remain out of reach (Randazzo, 2017). It is a problem that is a revolving door. To stop it, education programs that work at the local level will improve student access, engagement, performance, an evaluation (Randazzo, 2017). Improvement of the areas aligns to Chapter 2, Review of Literature, Technology Leadership, Productivity, and Practice in Texas.

#### **Theme 4: Not Leveraging Technology Most Effectively as a Barrier**

Understanding STEM technology is becoming more and more critical in the workplace and other areas. Competing with peers in the 21st century demands technological skill. Not using STEM technology most efficiently can be a barrier to opportunity. Acquiring STEM technology improvements can be a problem for schools as well (Heick, 2016). Some schools cannot keep up with the changing technologies related to STEM. Upgrading equipment is costly as well as having the qualified individuals in place to manage it. Some educators choose not to use STEM technologies because of their belief is that they cause distractions. STEM technologies are not always perceived as a learning tool. Some teachers believe their control will be limited due to lack of monitoring and students playing games and participating in social media. Teachers further believe that STEM technologies disable students' intellect. STEM technologies are not used because answers are generated too easily. Unfortunately, some teachers believe technology does not allow students to think through the learning process (Heick, 2016). However, this study indicates that the tenets of STEM and technology implementation are interwoven and work together to build a bridge to prepare students for today's workforce industry.

#### **Theme 5: Location of STEM Programming as a Barrier (Lack of Access)**

Lack of support and access for STEM programs and teachers in K-12 schools will impact a state's ability to provide the quality workforce companies will require in that location (Castle, 2018). There are opportunity gaps for students in urban communities that have gone overlooked for decades and have negative impacts on students and teachers (Buffington, 2017). This urban perception on STEM education, as separate and distinct from a rural perception, is noteworthy because urban areas have not yet been a significant focus of STEM education initiatives (Carnegie Science Center, 2014).

STEM education is not powerful everywhere. Engaging students in STEM education through collaborative, hands-on, problem-solving and project-based methods will produce a high return for rural areas. Without STEM education, students from rural areas have fewer options and a limited future. Urban areas also lack resources to engage young people in STEM (Carnegie Science Center, 2014). Some educators' STEM dispositions are low, leading to misunderstandings about the objectives of STEM education.

### **Theme 6: Students' Lack of Skills as a Barrier**

Business leaders are less optimistic and feel like U.S. education system is not preparing students for jobs of the 21st Century. STEM is collaborative, hands-on, problem-solving, and project-based. Without practice, the skills are not developed or enhanced, which is necessary for STEM education. Students learn best through collaborative learning in groups. This approach mirrors the real-world professional social setting that students would experience in a career. When educators from different disciplines do not collaborate and teach as integrated teams, students will lack different perspectives (Carnegie Science Center, 2014). Hands-on activities give students several ways to discover, science, technology engineering, and math firsthand. Building a piece of work is way more engaging and interactive (Carnegie Science Center, 2014).

Students will substantially fail if they are not taught how to think critically and solve problems in STEM (Carnegie Science Center, 2014). STEM education consists of responding to undefined problems and challenges. Finding the answers advances problem-solving skills that are later applied in the real-world setting. Project-based learning means creating a product to solve the need. Instructors are present so students can receive support to complete the project. Project-based learning is a robust method of growing STEM skills for interest and out of the box

thinking (Carnegie Science Center, 2014). Several of the STEM principals in this research study rely upon project-based learning initiatives to enhance their instruction at their campuses.

### **Implications**

The findings from this study represent the principals' perceptions regarding technology implementation and STEM program sustainability. They also explain how principals expanded their knowledge about STEM education and the factors that are perceived as barriers to learning for STEM students. Further, they discuss the similarities and differences that the principals experienced at their campuses. As a result of these findings there are implications that principals and district personnel in this Texas Urban School District could consider as possible strategies for sustaining STEM programs in lieu of budget shortages. In doing this, principals ultimately become urban campus change agents and exhibit the components of researcher's conceptual framework. This includes the distributed cognition theory, the ISTE National Educational Technology Standards for Administrators, and the transformational leadership theory.

### **STEM Principals' Similarities**

In lieu of the budget cuts and effects from Hurricane Harvey, all of the STEM principals of this study spoke about the resources that were damaged or lost during this historical storm. Each principal had their own lines of contact and plans for replacing the STEM resources but would welcome the upgrades to technology and the latest innovative tools that will assist students and teachers during instruction and curriculum planning.

With regards to the budget cuts, the principals identified grants, community support, and other innovative ways to ensure that the funds would be available to support STEM on their campuses. Each principal expressed that cutting staff was always done as a last resort, and that it was done carefully and implemented as a temporary solution. The principals went on to explain



that they hired STEM staff very carefully and that they valued the talents and expertise of each individual as a valuable component to students' learning at their campuses.

As women in education and STEM leaders, Elementary Principal 1 and Middle School Principal 1 expressed their vision to support more females in the pursuit of STEM careers. Both principals have noticed that more females are showing interest in technology and engineering field components. This change has prompted these principals to partner with regional organizations like Code.Org and NASA. Both have pathways that help to encourage and support female students towards pursuing careers STEM.

At the middle school level, the STEM labs were just as evident as those at the high school levels. Middle School Principals 1 and 2 spoke about the lab components at their campuses and how they are both seeking stronger partnerships with businesses in the area. Both principals spoke about the support from high school students that return to campuses with counselors to speak to the middle school students about the STEM career pathways available to them.

The STEM high school principals in this study both spoke about the strong support that derives from alumni who have pursued STEM careers, and from those who have retired and live in the surrounding area. High School Principals 1 and 2 each have specific days and weeks that are reserved for alumni to come to campus to speak to and mentor STEM students. The principals have seen a large percentage of growth regarding the number of students who are attending colleges and universities for career preparation in STEM fields.

All of the STEM principals in this study spoke about each level across the K-12 infrastructure coming together to build a bridge of support for students, as they transition from elementary to high school. It was agreed that the overall challenge would be for all education stakeholders from students to community partners to come together to formulate such a plan. The

principals expressed that coherence would help to solidify any gaps with regards to funding, career pathways, and continuous support for STEM students throughout their education and beyond.

### **STEM Principals' Differences**

At the elementary and middle school levels, the STEM Principals expressed that they would like to acquire more resources for their campuses, specifically in technology. The high schools possessed more STEM resources and technology because of the State of Texas requirements and goals for students to become endorsed or licensed with a trade upon graduation (Texas Education Agency, 2016). High Principals 1 and 2 spoke proudly about the number of students that have graduated from their campuses with STEM endorsements and even with associate's degrees from their partners at the local Community College and four-year College. High schools will continue to operate and obtain funding for the continuum of STEM programs each year.

Elementary Principal 2 and elementary principal 1 expressed the importance of embracing the STEM to STEAM concept early, as an important foundational component to the programs existence at their campuses. As the STEAM concept is in its introductory stages, the researcher discovered that the middle and high schools are embracing the concept at slower a pace than at the elementary level. Elementary Principal 1, in particular, spoke about her school's partnership with the local Ballet and local Symphony, to address inclusion of the "Arts" component.

The high school campuses possessed more community and business partners than the elementary and middle school levels. The STEM principals from the elementary and middle school levels explained that they would like to increase partnerships in the surrounding

community and from business partners because these components help to build a stronger foundation for STEM students at their campuses. The elementary and middle school principals expressed the belief that it is never too early to involve the real-world into education.

### **STEM Sustainability and Funding Opportunities**

Elementary and secondary students are the least common group targeted by federal STEM education programs (Chiu, Price, & Ovrachim, 2015). Many schools are not provided with the needed facility structure, tools, equipment, or required instructional media to suitably support STEM (Ejiwale, 2013). There is also a potentially high financial cost and work commitment to retraining teachers and adapting pre-service teacher education programs to prepare for the implementation of integrated STEM education (Blackley & Howell, 2015). Allotting adequate amounts of funding to prioritize STEM education, as well as maintaining this funding, is not only crucial for STEM education, but for all education (Chiu, Price, & Ovrachim, 2015).

The U.S. Department of Education has a new focus on STEM education. The Trump administration's fiscal year 2019 budget request for the Department of Education prioritizes specific STEM education programs. The budget is directing The U.S. Department of Education to commit at least \$200 million annually. Starting in the fiscal year 2018, the support is for existing programs to activities that support STEM education and computer science education. The order is to give the U.S. Department of Education the preference to control grant programs it can use to meet requirements of the directive (Wolfe, 2018). The U.S. Department of Education is currently accepting applications for two fiscal year grant competitions that support the Trump Administration's goals to increase access to high-quality Science, Technology, Engineering and Mathematics (STEM) and Computer Science (CS) education (U.S. Department of Education, 2018). There are two grants up for competition. The Supporting Effective Educator Development

(SEED) program and Education Innovation and Research (EIR) program are expected to award a total of \$195 million for STEM education. Each program's main priority is STEM and Computer Science to reach those underserved communities and populations to support STEM educators. (Johnston, 2018).

### **STEM Mentoring Programs**

The U.S. Department of Education has established programs to increase accessibility to STEM education for all students (U.S. Department of Education, 2015). Mentoring has been shown to be a useful strategy for increasing student success (Borich, 2016). STEM mentoring varies from traditional mentoring practices. The objective is to engage and retain students in the STEM pipeline with a concentration on underrepresented minorities given their underrepresentation in STEM careers (The University of Texas at Dallas, 2017). Socialization practices have a tendency to impart a negative self-perception of ability. STEM mentoring relationships help to lessen nervousness, and address other common academic discouragements like fewer networking possibilities, poor preparation, and culture shock both as a student and as a member of a minoritized population (Zaniewski & Reinholz, 2016). Effective STEM mentoring programs have included peer mentors, professional mentors, and personal mentors. AT&T Aspire is AT&T's signature education initiative pushes innovation in education by bringing various resources to stand on the issue including funding, technology, employee volunteerism, and mentoring. A UT Dallas mentorship program is designed to support young women exploring careers in science, technology, engineering and math (STEM). The program continues to grow, thanks to AT&T Aspire partnership with eighty high schools students paired with college mentors and teachers (The University of Texas at Dallas, 2017).

### **Minority Focused STEM Organizations**

This Texas Urban School District is the seventh largest district in Texas with population demographic values of 61.84 % Hispanic, 24.02% African-American, 4.05% Asian, 8.07% White, and 74.93 % Economically Disadvantaged (HISD Demographic Campus Report, 2018). A multicultural STEM-focused career development framework is vital to inspire youths' career development and awareness of STEM education and careers for a practice aimed at increasing the attainment and achievement of diverse groups in STEM fields. STEM fields are imperative to improve the social and economic conditions of the country. STEM careers contribute innovations that improve living conditions (e.g., health care, clean energy) and account for more than half of the country's continued economic growth for the past 50 years (Byars-Winston, 2014). The societal and economic contributions of STEM fields are important in promoting STEM fields and increasing the number of STEM workers at the forefront of most national policy discussions.

Minority-focused STEM organizations that inspire and contribute to assisting minority students are NACME (National Action for Minorities In Engineering), MAD-learn, The Texas Instruments MathForward Program, National Academy Foundation, and Maker Ed (Popular Science, 2015). NACME is known as the largest provider of college scholarships for underrepresented minorities pursuing degrees at schools of engineering. Their mission is to enrich humanity with an American labor force that supports diversity in STEM by growing the number of underrepresented minorities in engineering and computer science. Their vision is to create an engineering workforce that looks like America. NACME works consists of associates with like-minded individuals to provide scholarships, resources, and opportunities for high-achieving, underrepresented minority college students aiming towards careers in engineering and computer science. By supporting their academic endeavors and professional development,

NACME produces well-qualified candidates that meet today's urgent hiring demands for more diverse STEM talent (NACME, 2013).

MAD-learn (MAD stands for Mobile Application Development) is a curriculum program directed at upper-level elementary, middle and high school students who are attracted to learning about the fundamentals of mobile app design and development. Merging traditional classroom methods with interactive online learning modules, MAD-learn is a progressive framework that offers creative opportunities for students of all skill levels (Crescerance Inc, 2017).

The Texas Instruments MathForward Program combines Texas Instruments' technology with coaching and professional development. Both educators and students are advantaged by the program. The MathForward program was produced to diminish the achievement gap between diverse student populations. The program has been applied equally in classrooms with proficient and struggling English Language Learners and Special Needs students (Texas Instruments Incorporated, 2017).

The task of the National Academy Foundation (NAF) is to create a sustainable national network of career academies to upkeep the development of America's youth. National Academy Foundation is a national network of education, business, and community leaders who work together to maintain high school students are college, career, and future ready. NAF solves some of the biggest challenges facing education and the economy by bringing education, business, and community leaders together to transform the high school experience (NAF, 2017).

Maker Ed is a national nonprofit organization that provides educators and institutions with the training, resources, and community of support they need to produce engaging, inclusive and motivating learning experiences through maker education. Maker Ed uses a wide diversity of hands-on, engaging activities like construction, computer programming, and sewing to assist

academic learning and the development of an attitude that values playfulness and experimentation, growth and iteration, and collaboration and community (Maker Ed, 2017).

Participants build a physical or digital artifact and then share it with a larger audience.

In congruence with the elementary, middle, and high school principals perceptions, these programs can serve as resources, partnerships, and opportunities for STEM students and campus staff members. These organizations consistently focus upon the latest trends in STEM and also seek to serve urban campuses that are experiencing challenges financially and socio-economically. Many of these organizations also possess connections or pathways to grants that are available for STEM campuses to use towards enhancing or updating their technology resources.

### **Recommendations for Action**

As sustainability strategies across the K-12 infrastructure the STEM, principals from the elementary, middle, and high school levels mentioned stronger partnerships and collaborations. Several STEM campuses within this Texas Urban School District have partnered with organizations in the surrounding region with an emphasis on resources and professional development. However, the need for a partnership that doubles as a “one stop shop” is necessary to provide consistent STEM support for all STEM stakeholders across the board. In partnering strategically, the Urban STEM Campuses can save funds, maximize resources, and receive consistent support with the latest trends and innovative techniques for students.

### **Project Lead the Way Action Plan**

Current research in project-based learning illustrates that these initiatives can increase student interest in science, technology, engineering, and math (STEM) because they engage students in solving actual problems, working with others, and producing real world solutions

(Fortus, Krajcikb, Dersheimerb, Marx, & Mamlok-Naamand, 2005). STEM principals need plans that will align with the needs of the campus and will offer a continuum of support (Project Lead the Way, Inc., 2018). Established in 1997, the American nonprofit organization, Project Lead the Way (PLTW), is dedicated to empowering students and renovating the teaching experience. Since its inception, PLTW has developed from a high school engineering program to offering comprehensive K-12 pathways in engineering, computer science, and biomedical science (Project Lead the Way, Inc., 2018). The STEM education program is a STEM pathway that offers a problem-based curriculum combined with a teacher and staff professional development. PLTW students engage in STEM hands-on activities, projects, and problems that are reflective of real-world challenges later applied in STEM careers (Project Lead the Way, Inc., 2018).

PLTW Launch (K-5) is an aligned kindergarten through fifth-grade elementary STEM program that enables students to implement a design-thinking mentality through captivating activities, projects, and problems (Project Lead the Way, Inc., 2018). These concepts grow upon each other and relate to the world around them. The program is divided into twenty-four interdisciplinary modules throughout kindergarten and fifth grade. The modules range from Pushes and Pulls, Light and Sound, The Changing Earth, Stability and Motion: Forces and Science and Flight, Energy: Collisions, Robotics and Automation (Project Lead the Way, Inc., 2018). As students interact with hands-on activities in computer science, engineering, and biomedical science, they become creative; collaborative problem solvers, and prepared to take on any task. Elementary students by this time have the makings of becoming great innovators. PLTW Launch (K-5) persuades the youths' investigative inkling and engages youngsters in learning that feels like play, while motivating their drive and determination to keep discovering into the future (Project Lead The Way, Inc., 2018).

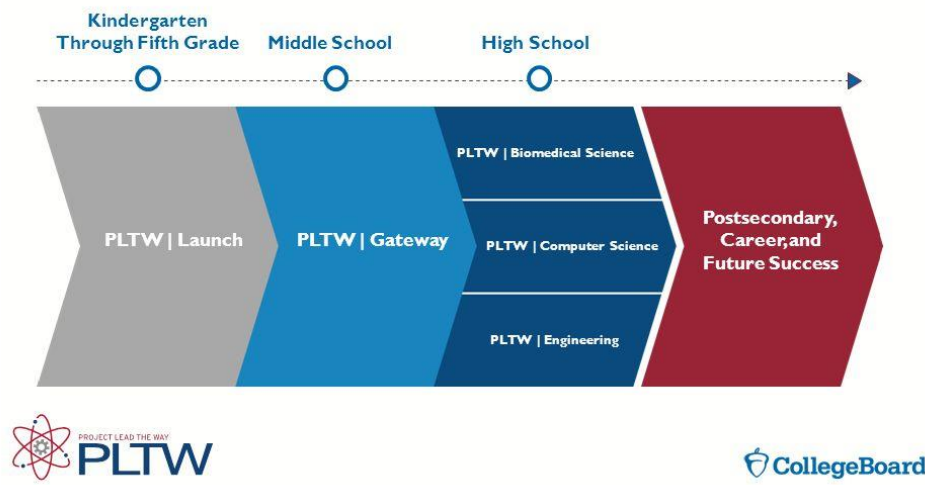


PLTW Gateway (6-8) is an aligned sixth-grade through eighth-grade middle school STEM program that allows middle schoolers to be in charge of their discovery (Project Lead the Way, Inc., 2018). Like PLTW Launch (K-5), it too is a STEM hands-on program that strengthens school engagement and excitement. The program is separated into ten STEM units. The units are Design and Modeling, Automation and Robotics, App Creators, Computer Science for Innovators and Makers, Energy and the Environment, Flight and Space, Science of Technology, Magic of Electrons, Green Architecture, and Medical Detectives (Project Lead the Way, Inc., 2018). These components work together, while pushing collaboration, inspiration, and comprehension (Project Lead the Way, Inc., 2018). These students have the opportunities to pursue various paths and possibilities that await them in high school and beyond (Project Lead the Way, Inc., 2018).

PLTW (9-12) Computer Science, Engineering, and Biomedical Science are three separate advanced placement (AP) pathways for high school students (Project Lead the Way, Inc., 2018). PLTW (9-12) Computer Science allows high school STEM students to become creators rather than customers of the technology that surrounds them. Even at this level students are still exposed to exciting, real-world challenges. They collaborate to design solutions, while learning computational thinking, which is more than coding (Project Lead the Way, Inc., 2018). Students are thinking critically and communicating cross-culturally. PLTW Computer Science (9-12) units are Computer Science Essentials, Computer Science Principles, Computer Science A, and Cybersecurity (Project Lead the Way, Inc., 2018). PLTW (9-12). Engineering prepares students by engaging them to solidifying real-world scenarios (Project Lead the Way, Inc., 2018). These STEM hands-on activities groom students to be collaborators, thinkers and problem solvers. PLTW (9-12) Engineering is a nine-unit STEM program. The units are Introduction to

Engineering Design, Principles of Engineering, Aerospace Engineering, Civil Engineering and Architecture, Computer Integrated Manufacturing, Computer Science Principles, Digital Electronics, and Environmental Sustainability (Project Lead the Way, Inc., 2018). PLTW (9-12) Biomedical Science works with the exact tools used by medical professionals in hospitals and labs. Students perform hands-on activities like today's biomedical professionals. Students participate in a four-unit STEM program. The units are Principles of Biomedical Science, Human Body Systems, Medical Interventions, and Biomedical Innovation (Project Lead the Way, Inc., 2018). At this level, students have the opportunity to partner with nearby colleges and hospitals to pursue internships and camps for introductory experience in their prospective pathways (Project Lead the Way, Inc., 2018). In doing this partnering, they become enabled to network and form mentoring relationships that continue to motivate them towards successfully landing a position and performing in STEM related fields. Figure 5.1 below displays the components of the Project Lead the Way Program. In congruence with the elementary, middle, and high school principal responses for Research Question 2, the components of this program could be used as valid strategies to incorporate at STEM campuses, while increasing partnerships, resources, staff development possibilities, and sustainability in challenging times.

# PLTW'S K-12 CURRICULAR PATHWAYS



*Figure 5.1: Project Lead the Way Curricular Pathways. This figure depicts the components that complete the K-12 strategic action plan for STEM program implementation.*

## Recommendations for Further Research

This qualitative study was descriptive and based on the perceptions of principals from the elementary, middle, and high school levels. The researcher identified additional areas within technology and STEM that provides opportunities for further investigation. Conducting a qualitative case study on women and minorities in STEM would enrich the body of knowledge and would explore how STEM is transitioning from its traditional modalities to include a more culturally diverse population.

As STEM transitions to STEAM, thus including the arts, debates continue within the educational infrastructure and within workforce development (Land, 2013). Many are questioning whether the arts belong and how do they play a role with the other components? The researcher continues to assert however, that technology builds the bridge that connects all subjects today (Sheninger, 2014). A case study exploring the perceptions of STEM versus STEAM would help to further understand the rationale of adding the arts.

## **Women and Minorities in STEM - Underrepresented Minorities**

African Americans, Native Americans, Alaska Natives, and Latinos historically consist of a minority of the U.S. population. Women and minorities are increasing in number and influence. Currently, these populations of color constitute 30 percent of the U.S. population. However, by 2050, these populations will account for greater than 40 percent of the U.S. population. Minorities are underrepresented in the fields of science, technology, engineering, and mathematics (STEM) (NACME, 2013). The majority of STEM workers have a science or engineering college degree. Underrepresentation amid science and engineering majors could contribute to the underrepresentation of women, Blacks, and Hispanics in STEM employment. While these underrepresented populations have made some modest gains over the last several decades, their progress has been plodding. Worse, over the last decade, African Americans' development in achieving bachelor's degrees in engineering, mathematics, computer science and physics has diminished or even reversed (Klawe, 2015). Women and minorities are unequally underrepresented in STEM degree attainment and the STEM workforce (Holdren, Marrett & Suresh, 2013). Enhancing the involvement of women and minorities in STEM is one way to assist in closing the STEM gap. To improve the gap and promote longevity and staying power for STEM, powerful solutions are needed for change. The recommendation is for robust implementation of STEM pipeline programs, traditional STEM mentoring programs and minority-focused STEM organizations. Social support is a step in the right direction. Such efforts will help dismiss the stereotypes that minorities can only succeed in the world of athletics or entertainment. The STEM fields are one of the limited areas where there is job development (U.S. Department of Education, 2015). If the opportunity to include underrepresented minorities in this renewed emphasis on the STEM fields is not capitalized, minorities in the U.S. will

continue to face economic inequality. Lack of qualified STEM professionals jeopardizes economic progress.

### **STEM to STEAM**

STEAM refers to science, technology, engineering, arts, and mathematics. The drive for the STEAM education arises from the loss of creativity and innovation in recent college graduates in the United States. Currently, our education system requires students to execute given tasks fluidly, but rarely fosters curiosity and self-motivation (Land, 2013). Advancement does not come from technology alone, but the melding of technology and creative thinking through art and design. As long as an individual is pushing personal limits and forming his or her conceptual methodologies innovatively, they can have a creative practice in any field.

Moreover, the arts can help develop STEM skills because of the more divergent approach. STEAM is cross-curricular collaboration. Each subject area is recognized as having a role in supporting learning. Applications of STEAM in learning include circuit bending, musical compositions, kinetic art, product design, prototype development, and performance art. STEAM gives students beyond high-tech skills. Complex systems and answers are intellectualized and designed with predominately investigative skills with an aspiration to be transitioned into applied proficiencies given the business- and mission-significance of more artistic and ingenious skills. The combination of arts and sciences produces a unique skill set that can improve these transitional outcomes. Integrating the arts into the STEM curriculum provides pathways for personal meaning-making and self-motivation (Land, 2013).

### **Limitations**

The design of this qualitative study included limitations based upon the timing of the research in academic year, the standardized testing season, and the approval process by this

Texas Urban School District's Office of Research and Accountability. The principals selected for this study were chosen based on those that responded to the Informational Letter Invitation in Appendix A. Due to time constraints, one of the STEM principals at the elementary level ultimately decided not participate in the study. The Office of School Leadership helped the researcher to identify another STEM principal with campus leadership experience at the elementary level who was willing to share his perceptions.

To avoid bias, the researcher created categories that focused on the study's research questions. Creswell (2013) asserted that constructing theme categories poses the potential challenge of identifying a recurring pattern that cuts across the data from the study (p. 181). Furthermore, Creswell (2013) explained that categories should be responsive to answer the research questions; sensitive to the data as possible; exhaustive enough to encompass all relevant data; mutually exclusive to where data can be placed in one category; and conceptually congruent across all categories. In doing this, the vulnerability of errors was lessened that could derive from judgment (Creswell, 2013)

### **Summary**

At the inception of this study in 2016, this Texas Urban School District faced a 107 million dollar budget shortfall. As of today it faces a 115 million dollar deficit. District personnel and principals have been directed once again to review their respective budgets to determine where potential cuts could be allocated. Many of the cuts have led to the reduction of school curriculum electives and the STEM education program offerings with a reduction in resources and staff members qualified to teach in STEM-specific areas. The purpose of this qualitative study was to describe the perceptions of urban district principals regarding technology implementation and identify recommendations for the sustainability of STEM programs within

this Texas Urban School District. As a result of the elementary, middle, and high school STEM principal interviews, the researcher was able to describe their perceptions regarding technology implementation and STEM program sustainability factors.

As technology advances, the potential outcomes for STEM program development and are multitudinous (Burns, 2013). Leaders must establish a clear vision while executing a process that includes technological savviness, global awareness, communication, stakeholder engagement, and innovation. This extends the premise for learning inside urban school districts and beyond. Technology implementation within the STEM concept has had a large effect on students' career choices. This effect now influences how society operates (Burns, 2013). As a result of this effect, principals and educators alike must be equipped to prepare students for today's societal demands. Virtual innovation has made our reality progressively complex, which has changed the requirements for individuals matriculating into today's professional industries. This change has made it necessary to ceaselessly provide learning areas that support critical thinking and school improvement. As interwoven concepts, technology implementation and STEM education programs continue as a catalyst to provide learning opportunities where stakeholders are more inspired, correspond consistently, and have chances to utilize critical thinking strategies that are associated with today's real-world trends.

As a final reflection, STEM careers are becoming more prominent in today's workforce. The sentiments of the STEM principals in this study was shared by the researcher that technology implementation is indeed a vital component in urban education. Collectively, STEM learning cannot reach its highest potential if principals lack access due to funding or dispel the perception that represses technology's utilization (Fairlie, 2012; McNierney, 2004; McHale, 2007). Technology implementation and STEM program sustainability can be increased through

programs and businesses that provide STEM resources, higher education contacts, and career pathway opportunities consistently (Project Lead the Way, Inc., 2018). This also helps to lessen the barriers to learning for STEM students in underprivileged areas as they pursue. Continuous professional development and training is needed in STEM education, as the workforce grows and as technology evolves (NAF, 2017). The principals' responses provided the researcher with qualitative data to make recommendations to urban STEM campuses and the Office of School Leadership within the Texas Urban School District. This study ultimately supported that the finding that tenets of STEM education and technology implementation are interwoven and work together to build a bridge to prepare students for today's workforce.



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## Appendix A

### Informational Letter

**Project Title:** “A Study of Urban Principals’ Perceptions of Technology Implementation and STEM Program Sustainability”

**Principal Investigator(s):** David D. Colter, (713) 703-5471 or dcolter@une.edu

**Faculty Advisor:** Dr. Michelle Collay, (207) 602-2010 or mcollay@une.edu

Dear Potential Study Participant:

As a doctoral student completing his dissertation through the University of New England, I am inviting you to *complete an interview to share your input on your current practices with technology implementation and STEM Program Sustainability at your respective campus*.

As the principal and leader of your campus, you have significant experience and knowledge of continuously providing urban district stakeholders with accessibility to technological resources and ISTE aligned STEM curricula, which ultimately helps to support their development in becoming producers and evaluators of knowledge. Most importantly, students develop the skills they need to compete in today’s technologically demanding economy.

This study focuses primarily on your perception as an urban principal regarding technology implementation and seeks to identify recommendations for the sustainability of STEM programs. By completing this interview, you are providing a valuable contribution to the reform of Urban District STEM Program practices and the continuous development of the Office of School Leadership School Leader Training Initiatives.

**Research Questions:**

1. What are the perceptions of principals regarding the implementation of technology within urban schools?
2. What are the perceptions of principals regarding the sustainability of STEM programs within urban schools?
3. How do urban principals develop knowledge about STEM education?
4. What are the perceptions of principals regarding barriers to learning for STEM students?

**Study’s Purpose:** The purpose of this qualitative study will be to describe the perceptions of urban district principals regarding technology implementation and identify recommendations for the sustainability of STEM programs within this Texas Urban School District System.

**Procedures:** Your participation in this research study is completely voluntary. The study includes a face-to-face or phone interview. The researcher and participant will explore the consent form at the beginning of the scheduled interview time, and will execute it thereafter. The researcher will need to obtain a signed consent form in person or electronically if the interview is conducted by phone. The interview will be forty-five minutes long and will be captured using the audio application Recordator. The study will commence from March 2018 to April 2018, with results/findings published by May 31, 2018.

Upon your request, I can send you a copy of your interview transcript and a copy of the completed dissertation. I do not foresee this study presenting any risks or hardship on you, other

than the time to invest in it. However, your time invested will contribute to the anticipated benefits of collecting this data to share with other urban district systems, with regards to technology implementation and STEM program sustainability. Together, we can address the growing disconnect between the skills that employers need in a rapidly increasing technological world and ensure that all students are able to succeed across the STEM disciplines.

**Confidentiality:** Your identity will be protected throughout the study and thereafter. Only I, the researcher, will have access to your information. Follow-up verbal/signed and written reports and discussions will identify your campus education level as a pseudonym (i.e. Elementary #1, Middle School #1, and High School #1). Your name and school location will not be shared with anyone else. Your confidentiality will be protected in compliance with the University of New England's Research with Human Participants' Policies and Procedures.

**Compensation:** No monetary or non-monetary compensation will be provided for your input or time.

**Questions:** If you have any questions or concerns regarding this study and your participation, you may contact me, the researcher, via e-mail at [dcolter@une.edu](mailto:dcolter@une.edu), or via phone at (713)-703-5471. You also may contact Dr. Michelle Collay at the University of New England at [mcollay@une.edu](mailto:mcollay@une.edu) or by phone at (207)-602-2010.

Thank you for your insight and willingness to participate in this research study. Your contribution not only supports my dissertation study, but also future sustainability strategies for urban district technology implementation STEM program sustainability.

Sincerely,

*David D. Colter*

David D. Colter, Doctoral Student  
University of New England's Transformative Leadership Program

## Appendix B

### CONSENT FOR PARTICIPATION IN RESEARCH

**Project Title:** “A Study of Urban Principals’ Perceptions of Technology Implementation and STEM Program Sustainability”

**Principal Investigator(s):** *David D. Colter*

**Faculty Advisor:** *Dr. Michelle Collay*

#### **Introduction:**

Please read this form. The purpose of this form is to provide you with information about this research study, and if you choose to participate, document your decision. You is encouraged to ask any questions that you may have about this study, now, during or after the project is complete. You can take as much time as you need to decide whether or not you want to participate. Your participation is voluntary.

#### **Why is this study being done?**

This study is intended to describe the perceptions of urban district principals regarding technology implementation and identify recommendations for the sustainability of STEM programs within this Texas Urban School District. The researcher has uncovered findings that suggest a threat to the longevity of STEM programs within Texas Urban School District

#### **Who will be in this study?**

Urban principals who lead at STEM campuses at the elementary, middle, and high school levels are being asked to participate in this study. STEM principals will be invited to interview independently (This is the total number of participants equaling: 2 elementary school principals, 2 middle school principals, and 2 high school principals).

#### **What will I be asked to do?**

Principals will be asked to participate in an individual interview, which should last forty-five minutes. These interviews can be scheduled in person or, if need be, over the phone. The interviews will be audio recorded for research purpose

**What are the possible risks of taking part in this study?**

Individual interviews will be kept confidential. No participant names will be used associating them with their responses to interview questions.

**What are the possible benefits of taking part in this study?**

By participating in this study principals are helping to shape technology implementation and identify recommendations for the sustainability of STEM programs within this Texas Urban School District System. This information could be used to assist The Office of School Leadership in developing meaningful professional development for principals at STEM Campuses.

**What will it cost me?**

This study will not require any type of cost owed by participants at any time.

**How will my privacy be protected?**

During interview sessions only the researcher and participant will be present. Information obtained during this study will be used only for the purposes of this study.. No participant names will be used within this study.

**How will my data be kept confidential?**

Individual interviews will be kept confidential. A copy of your signed consent form will be maintained by the principal investigator for at least 3 years after the project is completed before it is destroyed. The consent forms will be stored in a secure location that only members of the research team will have access to and will not be affiliated with any data obtained during the project. The audio application Recordator will be used to capture all interview sessions. These recordings will be transcribed and used only by the researcher for the purposes of this study. Research findings will be provided to participants at the conclusion of this study as requested.

**What are my rights as a research participant?**

Your participation is voluntary. Your decision to participate will have no impact on your current or future relations with the Texas Urban School District. You may skip or refuse to answer any question for any reason. If you choose not to participate there is no penalty to you and you will not lose any benefits that you are otherwise entitled to receive. You are free to withdraw from this research study at any time, for any reason. If you choose to withdraw from the research there will be no penalty to you and you will not lose any benefits that you are otherwise entitled to

**Whom may I contact with questions?**

The researcher conducting this study is David D. Colter. For questions or more information concerning this research you may contact him at (713)-703-5471 or [dcolter@une.edu](mailto:dcolter@une.edu). If you choose to participate in this research study and believe you may have suffered a research related injury, please contact the Faculty Advisor, Dr. Michelle Collay at (207) 602-2010 or [mcollay@une.edu](mailto:mcollay@une.edu). If you have any questions or concerns about your rights as a research subject, you may call Olgun Guvench, M.D. Ph.D., Chair of the UNE Institutional Review Board at (207) 221-4171 or [irb@une.edu](mailto:irb@une.edu).

**Will I receive a copy of this consent form?** You will be given a copy of this consent form.

---

**Participant's Statement**

**I understand the above description of this research and the risks and benefits associated with my participation as a research subject. I agree to take part in the research and do so voluntarily.**

---

Participant's signature

---

Date

---

Printed name

**Researcher's Statement**

**The participant named above had sufficient time to consider the information, had an opportunity to ask questions, and voluntarily agreed to be in this study.**

---

Researcher's signature

---

Date

---

Printed name

## Appendix C

### A Study of Urban Principals' Perceptions of Technology Implementation and STEM

#### Program Sustainability Principal Interview Guide

David D. Colter, Researcher

1. What is your age range? 21-30, 31-40, 41-50, 51-60
2. How many years have you been in education?
3. How long have you been an Urban Campus STEM Principal?
4. Discuss your role as a STEM principal. **(Visionary Leadership) (Distributed Cognition) (Idealized Influence, Individualized Consideration, Intellectual Stimulation, Inspirational Motivation)**
5. What is your understanding of STEM education? **(Excellence in Professional Practice) (Distributed Cognition) (Idealized Influence, Individualized Consideration, Intellectual Stimulation, Inspirational Motivation)**
6. What is your perception of technology implementation within this Texas Urban School District? **(Digital-Age Learning Culture & Systematic Improvement)(Distributed Cognition) (Distributed Cognition) (Idealized Influence, Individualized Consideration, Intellectual Stimulation, Inspirational Motivation)**
7. What is your perception of the sustainability of STEM programs within Texas Urban School District? **(Digital-Age Learning Culture & Systematic Improvement)(Distributed Cognition) (Distributed Cognition) (Idealized Influence, Individualized Consideration, Intellectual Stimulation, Inspirational Motivation)**
8. Describe the approaches that have been implemented at your campus to sustain STEM education within a strict budget. **(Digital-Age Learning Culture, Systematic Improvement,**

**and Visionary Leadership) (Distributed Cognition) (Idealized Influence, Individualized Consideration, Intellectual Stimulation, Inspirational Motivation)**

9. Discuss the barriers to learning for STEM students from your perspective as an urban school principal. **(Digital-Age Learning Culture and Systematic Improvement)**

10. What opportunities or resources have allowed you to further your knowledge about STEM education? **(Excellence in Professional Practice) (Distributed Cognition) (Idealized Influence, Individualized Consideration, Intellectual Stimulation, Inspirational Motivation)**

11. Discuss the support that has been available to you regarding STEM programs and technology? **(Excellence in Professional Practice) (Idealized Influence, Individualized Consideration, Intellectual Stimulation)**

12. What technologies are implemented on your campus and how do they align to STEM education? **(Digital-Age Learning Culture) (Distributed Cognition) (Idealized Influence, Individualized Consideration, Intellectual Stimulation)**

13. What are your wishes for technological implementation with regards to STEM education? **(Visionary Leadership) (Distributed Cognition) (Intellectual Stimulation, Inspirational Motivation)**

14. Discuss the implications for STEM education, as it relates to student learning, professional practice, systematic improvement, and visionary leadership. **(Idealized Influence, Individualized Consideration, Intellectual Stimulation, Inspirational Motivation)**



## Appendix D

### *Frequency of Themes for Research Question 1*

Theme	Number of interviewees mentioning this theme	Total exemplar quotes
STEM skills and technology for students are imperative	6	14
Students must have hands-on STEM experience	4	8
More STEM technology is needed	4	4
Exposing students to STEM early sets the stage	3	4
Engaging and empowering girls in STEM is important	3	4

## Appendix E

### *Frequency of Themes for Research Question 2*

Theme	Number of interviewees mentioning this theme	Total exemplar quotes
Partnering and collaborating to facilitate STEM increases sustainability	4	15
Engaging stakeholders is a key to sustainability	6	11
Principals' STEM vision is part of sustainability	4	6
Resources are needed for sustainability	4	5
Leveraging teachers' expertise increases sustainability	3	4

## Appendix F

### *Frequency of Themes for Research Question 3*

Theme	Number of interviewees mentioning this theme	Total exemplar quotes
Education, professional development, and training	6	14
Principals do their own research	4	6
Principals and staff receive coaching	5	4

## Appendix G

### *Frequency of Themes for Research Question 4*

Theme	Number of interviewees mentioning this theme	Total exemplar quotes
Lack of funding is a barrier	5	10
Lack of adequate STEM staff is a barrier	5	8
Lack of resources can be a barrier	3	4
Not leveraging technology most effectively can be a barrier	3	3
Location of STEM programming can be a barrier	3	4
Students lack of skills can be a barrier	3	5

## Appendix H

# The state of WOMEN IN STEM CAREERS



A 2017 report from LinkedIn on female representation in science, technology, engineering and medical (STEM) professions found women remain under-represented, and the gap begins in college.

### DEGREE DISCREPANCY

Women pursue degrees more frequently than men in education (64%), sociology (57%) and language/literature (62%). The numbers are reversed for engineering (19%), computer science (23%) and math (33%).



### THE POWER OF THE BOARDROOM

According to DeLoitte's 2016 Board Diversity Census, women filled 20% of board seats at Fortune 500 companies. Women occupied 5% of CEO spots at S&P companies.

### WOMEN: UNDER- REPRESENTED

Only 27% of the workforce in software and IT development is women. Only 17% of leadership in that industry is women.



### HEALTHCARE SETS THE PACE

Women make up 41% of leadership and 60% of the workforce in the healthcare industry. More than 50% of healthcare graduates are women.

### A LONG ROAD AHEAD

According to the 2017 Global Gender Gap Report from the World Economic Forum, the economic gender gap in STEM professions will take 217 years to close. There are no quick fixes, but the demand for women in STEM continues to increase.



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