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Initiating Change: An Investigation of Elementary Educators' Perspectives For Implementing STEM Innovation

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INITIATING CHANGE: AN INVESTIGATION OF ELEMENTARY EDUCATORS' PERSPECTIVES FOR IMPLEMENTING STEM INNOVATION

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Abstract

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STEM education has become a preferred curriculum design for integrating science, technology, engineering, and mathematics into k-12 instruction (Meyrick, 2011). Nonetheless, many elementary schools do not utilize the curriculum design and the benefits of learning it may provide, even though elementary educators understand the importance of science literacy starting in early childhood (Cafarella, McCulloch, & Bell, 2017; Worth, 2010). For many educators, the traditional instruction received as a child was instruction in isolation. This vision has led educators themselves to teach in isolation. Research has shown educators had little or no direction in how to switch their instructional practices from traditional learning practices into inquiry-based interdisciplinary STEM learning (Epstein & Miller, 2011). Through an explanatory sequential mix methods study, the research's purpose was to investigate elementary educators' perspectives of implementing STEM innovation in three area elementary schools including the strengths and challenges associated with implementation. Furthermore, the study aimed to describe to what extent elementary educators are supported through the implementation process as well as how the innovation could be further supported in the elementary classroom. Findings of the study showed many elementary educators are willing to change practices to accommodate STEM innovation; however, a lack of STEM understanding has affected their interpretations and perspectives of the innovation.

Keywords: STEM innovation, interdisciplinary, support for STEM education, challenges of implementing STEM innovation, successes of implementing STEM innovation, STEM growth-mindset, STEM instructional practices, inquiry-based learning, problem-based learning, engineering design process, active learning

Table of Contents

Appendices

Tables

Figures

Chapter 1: Introduction

Introduction to the Study

In 2015, President Barack Obama acknowledged science is more than a subject taught in school and more significant than the elements found on the periodic table (U.S. Department of Education, n.d.). "It is an approach to the world, a critical way to understand and explore and engage with the world, and then have the capacity to change that world" (U.S. Department of Education, n.d., para. 1). This progressive thinking to change the world has led many educational institutions across the globe to increase their attention to science, technology, engineering, and mathematics (STEM). Even elementary schools are striving to create opportunities through which younger students explore the tools needed to prosper in becoming STEM literate (Cox, n.d.); however, this change in curricular focus can be challenging for educators who had no experience with the STEM vision as a student (Fryer, 2015).

Background to the Study

For many educators, the traditional instruction received as a child was instruction in isolation. This vision has led educators themselves to teach in isolation. Fryer (2015) pronounced that many educators isolate learning because they "are used to siloed learning in different content areas" (para. 7) themselves. These experiences shaped the vision of teaching and education for many educationalists (Fryer, 2015). STEM, however, is designed not to be taught in different content areas (Fryer, 2015). Unlike traditional classrooms, the STEM classroom is designed to be integrated and interdisciplinary. This approach uses real-world struggles and challenges to link two or more subjects (U.S. Department of Education & American Institutes for Research [AIR], 2016). Changing an

educators mindset, however, to include the integrated and interdisciplinary STEM mindset can be difficult.

Mindset, according to Dweck (2006), involves how a person views and handles situations. Their mindset plays a part in either success or failure. People can express one of two mindsets: fixed or growth. A fixed mindset assumes an individual's character, aptitude, and innovation abilities are stagnant (Dweck, 2006; Popova, 2015). Therefore, the individual cannot change expressively; they are "fixed" in how they view or perceive meaning (Dweck, 2006; Popova, 2015). A growth mindset, however, is expressed by a person who prospers when faced with challenges and sees mistakes as an opportunity to grow and learn (Dweck, 2006; Popova, 2015). These two mindsets expressed by educators can either hinder the development of interdisciplinary STEM content or can provide an opportunity to learn and grow, leading to an understanding of blending STEM content into a package that prepares students to be engaged and competitive in their learning (Discovery Education, 2018; Popova, 2015). Therefore, when schools implement change, such as the STEM innovation, an educator's mindset can lead them to success or failure of the implementation.

For many educators, their own experiences as students hinder their mindset for implementing the STEM innovation (Fryer, 2015). Additionally, this outcome impacts the number of students entering postsecondary STEM fields of study. For decades, the United States government led the charge to increase STEM pursuits in public education to help increase economic and educational competitiveness (Brophy, Klein, Portsmor, & Rogers, 2008; Congressional Research Service, 2006; Ehrlich, 2007; National Science Board, 2007); however, the United States continues to fall short in the number of students

entering STEM fields of study. Once the leader in the number of engineer graduates, the United States is now ranked third in the number of college students obtaining a degree in the STEM fields (DeJarnette, 2012). In fact, in 2016, China and India produced more STEM graduates than the United States and Europe (McCarthy, 2017). India produced 4.7 million graduates, and China came in second with 2.6 million (World Economic Forum, 2016). The United States rounded out the top three with only 568,000 graduates (World Economic Forum, 2016).

One reason for fewer students entering STEM fields involves exposure to STEM education in primary educational settings. SRI International (2018) pointed out that exposure to the STEM innovation is critical in the elementary years since this exposure leads to interest in the secondary and postsecondary years. Limited exposure, however, in the primary duration, can lead to restricted experiences and can reduce STEM interest (SRI International, 2018). An additional reason for fewer students entering STEM fields involves educator understanding of STEM education. Research conducted by Brown, Brown, Reardon, and Merril (2011) concluded STEM education is not well comprehended. Less than one half of administrators understand STEM education and what it entails (Brown et al., 2011). Even teachers of STEM classes had different levels of understanding concerning what is meant by STEM education (Brown et al., 2011).

Lack of STEM understanding has led educators to feel concerned about teaching STEM especially in the elementary classroom (Milgrom-Elcott & Blackwell, 2016). Research has shown educators had little or no direction in how to switch their instructional practices from traditional learning into interdisciplinary STEM learning (Epstein & Miller, 2011). Hall and Hord (2015) advised before expecting a change in

students, support needs to be provided for educators to change practice. Epstein and Miller (2011) defended this statement: For support to be meaningful, creative solutions need to be achieved and then learning opportunities can occur for students; however, "more often than not, the support needed for the change process over time is not forthcoming, or the leaders fail to facilitate effectively" (Hall & Hord, 2015, p. 87). Despite its benefits, the implementation of the STEM innovation is an innovation that has suffered implementation failure in many cases. For many public school districts, STEM courses are taught by educators who have received no STEM education opportunities (Ledbetter, 2012); therefore, students are not receiving a quality STEM learning experience.

Not receiving quality STEM professional learning experiences can result in educators putting forth little effort towards implementing the innovation. Regardless of legislation and government mandates, educators are the individuals who "will make or break any change effort" (Hall & Hord, 2015, p. 12). Support, or lack thereof, will either encourage an educator's growth mindset or allow the fixed mindset to take hold with regard to STEM education. Educators often need assistance in shifting their mindset and instructional practices. Without this support, success for the innovation could be prevented (Talley, 2017).

As mentioned previously, educators often instruct the way they were taught as students, and extending instructional practices outside of their own learning experiences can be challenging ("Changing mindsets: STEM is not content areas in isolation," 2015). STEM education is designed not to be taught in isolation; therefore, STEM education is not found in the traditional classroom. STEM education is an integrated hands-on

approach to learning in which students are immersed in a world of blended learning ("Changing mindsets: STEM is not content areas in isolation," 2015). Personal change is needed to implement an instructional practice that is unfamiliar. A teacher must change their whole perception of teaching and their role in the process. Black, Harrison, Lee, Marshall, and Wiliam (2003) added, "since the way a teacher teaches is inextricably linked with their own personality and identity, ultimately it means changing yourself" (p. 80). Changing this mindset takes practice and time. As Hall and Hord (2015) described, "change is a process, not an event" (p. 10). Regrettably, educators have not been given the appropriate time to make the necessary changes (Hall & Hord, 2015). Policy makers are constantly changing acts and mandates when it comes to the STEM innovation, and educators are unable to keep up.

Even students can influence a shift in an educator's mindset. Students themselves come with preconceptions about the way the world works. If their initial understanding is not engaged, they may fail to grasp new concepts and information or may memorize material for immediate purposes (e.g., the test) but revert to their preconceptions outside the classroom. Often, these preconceptions include stereotypes and simplifications. Nevertheless, they have a profound effect on the integration of new concepts and information.

> Unless the teachers really figure out what each student believes is true and confront their notions about the world, they will continue to hold on to many misconceptions, some of which will make it impossible for them ever to truly understand more complex phenomena that build on this prior knowledge. (Earl, 2013, p. 60)

The STEM innovation is a popular topic, and many individuals have weighed in on the issue, including legislators and government leaders who believe STEM innovations can build future success for America (Epstein & Miller, 2011; Teaching STEM, n.d.). Many believe STEM education provides the best way to ensure students are exposed to science, technology, and math, resulting in opportunities to increase America's competitiveness (Brophy et al., 2008; Congressional Research Service, 2006; Ehrlich, 2007; National Science Board, 2007; Teaching STEM, n.d.).

Statement of the Problem

Despite legislative directives to increase the STEM innovation, the nation has been undergoing a decrease in the number of individuals entering STEM fields (Teaching STEM, n.d.). Public education leaders realize the issue and are encouraging schools within their districts to shift their mindsets to include the STEM innovation; however, many schools today implementing the STEM curriculum design are those found in secondary educational institutes (DeJarnette, 2012; Murphy & Mancini-Samuelson, 2012). Initially, secondary schools used the integration of the STEM innovation to teach students identified as gifted or talented to help provide a challenging curriculum (Meyrick, 2011). Today, however, more secondary schools are realizing the STEM innovation provides opportunities for more than just gifted or talented students; it provides all students with hands-on learning, transforming their learning experiences (Lang, 2017). The STEM innovation itself "has emerged as one of the most sought-after curriculum designs for integrating science, technology, engineering, and mathematics into k-12 education" (Meyrick, 2011, para. 1). Empirical studies, involving STEM, have determined activities in which students apply knowledge using integrated skills to explain

and answer problems provide higher and more significant learning (Wai, Lubinski, Benbow, & Steiger, 2010). Nevertheless, many elementary schools do not utilize the STEM innovation and the benefits of learning it may provide, even though elementary educators understand the importance of science literacy starting in early childhood (Cafarella et al., 2017; Worth, 2010). Supporters of STEM in the elementary setting acknowledge science literacy takes time, yet the time is not provided adequately (Cafarella et al., 2017). In fact, the time provided for science instruction in the elementary classroom is decreasing (Blank, 2013). According to the 2012 National Survey of Science and Mathematics Education Report (2013), students in kindergarten through third grades only receive 20% of daily science instruction, and 35% of students in fourth through sixth grades receive daily science instruction.

Even with these low percentages, elementary educators are under intense pressure to increase students' scores on high-stakes tests (Popham, 2001); therefore, many teachers taught their students to answer questions correctly the first time or taught students to answer questions based on multiple choice answers. As a result of this pressure and way of teaching, innovation practices are placed on the backburner, and instruction focuses on high-stakes testing. Innovated learning experiences require one to think outside the box and make mistakes; therefore, these types of experiences are not fully utilized in the educational setting, due to their complex and time-consuming nature, especially in the science classroom ("What is STEM," n.d.).

> The problem of not educating the youth of today in STEM areas is not a new one. Our nation's young people are not acquiring the skills they need to excel in the fields of science, technology, engineering and math. That needs to change if we

> want to build a generation of workers who will make America a leader in innovation. Given the opportunity, today's youth can step up, become engaged, learn more, and become the inventors, rocket scientists and engineers of the future. (Sridhar, 2013, para. 6)

A rising number of experts in education are promoting implementing STEM instructional practices into curricular units (Chalmers, Carter, Cooper, & Nason, 2017). For elementary educators, this influence can have negative or positive effects based on their beliefs and attitudes of evolving instructional practices and implementing change. Many elementary educators are exposed to the math and sciences; however, many lack experiences in technology and engineering integration using these subjects (Chalmers et al., 2017).

Initiating STEM innovation practices requires a significant undertaking and planning, for the change requires many resources. Educators have access to some resources required in the change, but unfortunately, many schools lack the necessary resources to initiate the particular change (Nagel, 2013). Lack of these resources leaves educators unprepared for their implementation of the innovation. Policy makers in the United States have initiated many acts to increase STEM education, but access to quality STEM practices is at a deficit (Randazzo, 2017). "Today's job market demands workers to have a strong grounding in STEM" (Buffington, 2017, para. 3); however, with the lack of STEM access in many communities, a toll will be reflected in the nation's technological authority, its economy, and national security (Randazzo, 2017).

Purpose of Study

Educators are responsible for developing and nurturing interests as well as providing skills for students to succeed in a global world. Political endeavors are continuously focusing on increasing STEM knowledge in educational institutions, and many secondary schools are beginning to utilize the program; however, many elementary educators do not feel confident in their understanding of the program to begin the implementation process (Epstein & Miller, 2011; Marx & Harris, 2006). This lack of confidence has resulted in many educators being unable to shift their mindset to one understanding the STEM innovation. As a result, math and science scores in elementary schools are lower than average, even after legislation has increased funding for the innovation (Epstein & Miller, 2011). Elementary educators, however, are inadequately prepared for the STEM innovation and a need exists for progressing this level of interest to increase math and science scores (Epstein & Miller, 2011).

Additionally, supports for successfully implementing the innovation are scarce at the elementary level (Chiu, Price, & Ovrahim, 2015; Hansen, 2014). This results in the creation of a school culture in which successful implementation of the STEM innovation is limited (Chiu et al., 2015; Ejiwale, 2013); however, educators can collaborate in the development and implementation phase of the innovation to create authentic STEM classrooms (Basham, Israel, & Maynard, 2010; Chiu et al., 2015).

Pondering this research, this study investigated elementary educators' perspectives of implementing the STEM innovation in three area elementary schools. The research analyzed the STEM implementation perceptions and understandings of elementary educators including strengths and challenges associated with implementation.

The study also gathered information concerning to what extent elementary educators were supported through the implementation process as well as how the innovation could be further supported in the elementary classroom to make the process flow smoothly. Through the process of support for the innovation, four categories were explored: funding for the innovation at the local, state, and national level; professional learning opportunities; support with resources; and the mindsets of educators who happen to be resistant or acceptant to the change innovation.

An explanatory sequential mixed methods design was used throughout the study. The method of design allowed the researcher to research two phases. The first phase of research focused on quantitative data followed by qualitative research that built upon and explained the quantitative data in more detail (Creswell, 2014). Five different hybrid questions were analyzed in the study, with each question involving the collection of quantitative data first and then explaining the quantitative results with in-depth qualitative data. In the first quantitative phase of the study, survey data were collected from elementary educator participants of three elementary schools within a demographically diverse county, centrally located within North Carolina. The researcher-developed survey was used to evaluate elementary educators' perspectives and understandings of STEM implementation. It also attempted to characterize successes and challenges in implementing the innovation, determine supports expressed throughout the implementation phase, and learn how the STEM innovation could be further supported to increase success. The surveys were analyzed using descriptive statistical analysis. Independently, Likert scale, multiple response, and dichotomy response items were analyzed; and percentage frequency distributions were presented in tabular format.

Likert scale items also used mode to measure central tendency. Open-ended survey items were analyzed independently and coded. After completing the survey, educators were invited to take part in focus groups. To explain and gain in-depth knowledge concerning elementary educators' perspectives and understandings of the STEM innovation, each elementary school setting participated in a focus group session. Each session allowed the researcher to observe and listen to elementary educator input concerning STEM implementation (Ravitch & Riggan, 2017).

Research Questions

Science, mathematics, and technology educational practices have become an increasing focus for the academic and business communities in the United States. More and more, the economies of the nation and world are becoming dependent on the skill sets of those in the science and engineering world (National Research Council, 2007). Many schools are changing their instructional practices to meet the needs expressed by political decrees (Lang, 2017; The State of the Union Address, 2011). "But our primary and secondary schools do not seem able to produce enough students with the interest, motivation, knowledge, and skills they will need to compete and prosper in the emerging world" (National Research Council, 2007, p. 94). According to the National Research Council (2007), "thorough education in science, mathematics, and technology will start students on the path to high-technology jobs in our knowledge economy" (p. 134). STEM education is seen as the way of implementing this high-quality education; therefore, this study aimed to investigate elementary educators' perspectives of implementing the STEM innovation in three elementary schools as well as characterize successes and challenges associated with implementing the STEM implementation.

Creswell (2014) explained research questions are used to focus the purpose statement on objectives concerning what is discovered during the inquiry process. Creswell (2014) also argued mixed methods research questions are not inquiries that depend entirely on quantitative or qualitative research but a cooperation of both forms; therefore, this mixed methods research was designed to investigate the implementation of the STEM innovation inside three demographically diverse district elementary schools to determine to what extent elementary educators are prepared in implementing the STEM innovation. To aid in answering this primary question, five hybrid (integrated) quantitative and qualitative data research questions were used. The following research questions were used to guide the study:

1. How can elementary educators' perceptions and understandings of the STEM innovation be described?
2. To what extent are STEM instructional practices being implemented?
3. How do elementary educators characterize successes and challenges in implementing the STEM innovation?
4. To what extent are elementary educators supported in their implementation of the STEM innovation?
5. How could the STEM innovation be further supported in the elementary classroom?

Theoretical Framework

In using the mixed methods approach, the researcher based the research questions "on the assumption that collecting diverse types of data best provides a more complete understanding of a research problem than either quantitative or qualitative data alone"

(Creswell, 2014, p. 19); therefore, the mixed methods approach is supported by a theoretical lens. The theoretical framework for this research is grounded in the postpositivist paradigm. Created by combining two other theoretical frameworks, positivism and interpretivism, postpositivists believe the view of the world is constructed based on experiences (Panhwar, Ansari, & Shah, 2017; Web Center for Social Research Methods, 2006). This paradigm focuses on research using both quantitative (positivism) and qualitative (interpretivism) methods leading to a complex explanatory range of facts (Butin, 2010; Clark, 1998; Fischer, 1998). Flexible in nature, postpositivism allows the researcher to use either a qualitative, quantitative, or mixed methods approach to data collection depending on the question format (Henderson, 2011; Panhwar et al., 2017).

"Postpositivism suggests the turning of the empirical data of a neo-positivist/positivist results into knowledge through interpretative collaboration with other viewpoints" (Panhwar et al., 2017, p. 255). Through the selection of either qualitative, quantitative, or mixed methods, a researcher can answer a question based on the needs presented in the question (Creswell, 2014). "Thus, in the scientific method-the accepted approach to research by postpositivists-a researcher begins with a theory, collects data that either supports or refutes the theory and then makes necessary revisions and conducts additional tests" (Creswell, 2014, p. 7). The postpositivism theoretical framework stresses meaning and strives to bring together theory and practice by allowing the researcher to choose the best method suited for answering the research question (Ryan, 2006).

Through the postpositivist lens, research is collected through careful observations and measurements, studying the behavior of those involved in the research (Creswell,

2014). The participants provide the evidence of the research, and the collected information defines the knowledge of the research (Creswell, 2014). This theory allowed the researcher to assume the role of a learner. Postpositivists acknowledge their knowledge, background, and theories can influence the observations of the research (Robson, 2002). To decrease personal bias of the researcher and respondents, data collection used a multidisciplinary approach (Phillips & Burbules, 2000). Understanding bias and taking steps to reduce them aided the researcher in fairness (Deluca, Gallivan, & Kock, 2008; Fischer, 1998).

The postpositivist paradigm discards the idea that a person can view the world effortlessly (Web Center for Social Research Methods, 2006). The observations conducted can become biased, thus multiple perspectives are measured (Web Center for Social Research Methods, 2006). To organize these perspectives, Ravitch and Riggan (2017) suggested the conceptual framework provide a close association between the subject matter, inquiries, and methods. Research involving STEM implementation and integration also expressed a conceptual framework be used to connect how people learn (Kelley & Knowles, 2016); thus, the conceptual framework used to focus the postpositivist paradigm is a model of organizational change.

Developed by Kurt Lewin, the model of organizational change involves a three-step process that reflects an organization's change in the implementation process (Hussain et al., 2016). Figure 1 depicts Lewin's model of organizational change.

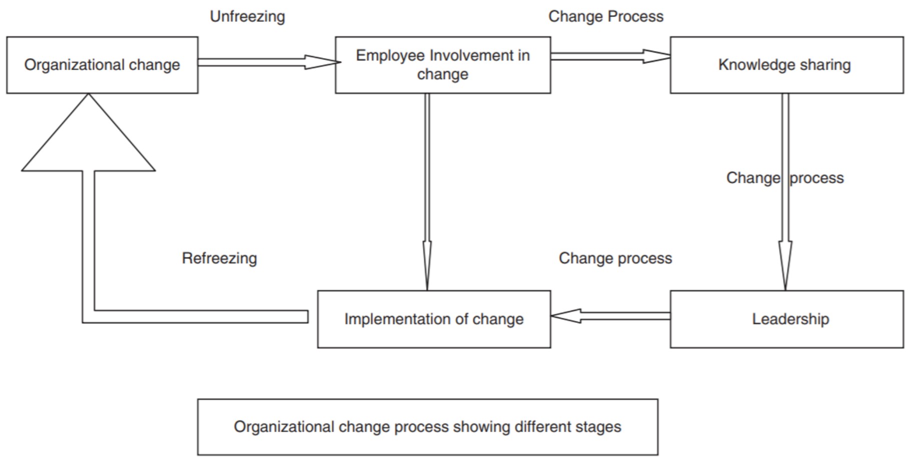


Figure 1. Kurt Lewin's Model of Organizational Change. This figure provides the model of organizational change and uses a three-step process to improve implementation procedures of an organization (Hussain et al., 2016).

To aid in the understanding of organizational change, Moran and Brightman (2001) defined change management as the practice of renewing the focus, configuration, and abilities of an organization so they may serve the changing needs of those they serve; thus, the model of organizational change correlates with elementary educators' needs to change and shift instructional practices towards the STEM innovation.

Organizational change and unfreezing. According to Alvesson and Sveningsson (2008), the world is ever changing; therefore, organizations must adapt and shift their way of thinking to survive in a global society, thus, the ever-changing mentality can lead to chaos, creating resistance to change in an organization (Glieck, 1987). However, internal or external pressures make the organization change, whether the stakeholders were prepared or not. To prepare for the change, the organization must go through the unfreeze phase. In this phase, the organization begins to prepare for the change, "which involves breaking down the existing status quo before you can build up a new way of operating" (Mind Tools Content Team, n.d., para. 7). To do this unfreeze,

organizations analyze data to show those involved in the change process the status quo cannot continue (Mind Tools Content Team, n.d.). The unfreezing phase is usually the most difficult for the organization because this phase challenges the attitudes and ideas already set in place (Hussain et al., 2016; Mind Tools Content Team, n.d.); however, without this phase, those involved in the change process might not partake (Mind Tools Content Team, n.d.).

Employee involvement in change and change process. Glew, Leary-Kelly, Griffin, and Van Fleet (1995) asserted this phase of the change process seeks to expand input from the members of the organization. Hussain et al. (2016) agreed with this statement "for overcoming the resistance in organizational change, the employee involvement is the oldest and most effective strategy in formulating the planning and implementing change" (p. 3). Involving employees in this phase will likely create commitment during the implementation, leading to motivation (Hussain et al., 2016). With this collaboration, ideas and information may be shared, leading to contribution with the innovation, creating a shared commitment for the innovation to occur (Hussain et al., 2016); however, to accept the innovation as a permanent change, those contributing to the implementation need to grasp how the innovation will be of value to them (Mind Tools Content Team, n.d.). Members who grasp the value of the innovation will move towards the implementation phase. Those who still have trepidations about the innovation move towards the knowledge sharing phase.

Knowledge sharing and the change process. Wenger, McDermott, and Snyder (2002) acknowledged that sharing knowledge among an organization is critical for understanding to occur. When members of the organization act as a team and work out

their insecurities with the innovation, understanding can begin to occur (Foss & Pedersen, 2002; Hakanson, 1993; Mind Tools Content Team, n.d.). Ambrosini and Bowman (2001) as well as Brown and Duguid (1991) revealed that in the phase of knowledge sharing, organizations do not depend solely on professional learning. The organization uses the knowledge one brings to the organization to lead to sharing of ideas, experiences, and proficiencies with the innovation.

Leadership and the change process. Once members of the organization begin to work together, exploring the innovation to be implemented, leadership becomes involved and motivates members in pursuit of the organization's goals (Hussain et al., 2016). Laura and Stephen (2002) maintained that during this phase, leadership works with individuals to overcome any difficulties that may be associated with the implementation or with fears the individual may express.

Implementation and refreeze process. Once members are on board with the innovation and leadership provides support, the organization can begin the implementation process, and refreezing begins to occur. In the refreezing phase, changes brought forth, based on the innovation, become a common occurrence (Mind Tools Content Team, n.d.). Those using the implemented innovation use it in daily occurrences and feel confident with the structure (Mind Tools Content Team, n.d.). During this phase, the innovation will need to be used without new innovations taking uproot. If new innovations were introduced at this point, members of the organization will begin to perceive change as a common occurrence and will less likely support change in the future (Mind Tools Content Team, n.d.).

Nature of the Study

In 2009, President Barack Obama propelled Educate to Innovate into focus (Obama White House Archives, n.d.). This initiative was to motivate students within the United States to become leaders in science and math (Obama White House Archives, n.d.). In 2011, President Barack Obama promoted STEM innovation during his State of the Union Address and declared "the first step in winning the future is encouraging American innovation" (para. 23).

> Half a century ago, when the Soviets beat us into space with the launch of a satellite called Sputnik, we had no idea how we would beat them to the moon. The science wasn't even there yet. NASA didn't exist. But after investing in better research and education, we didn't just surpass the Soviets; we unleashed a wave of innovation that created new industries and millions of new jobs. (The State of the Union Address, 2011, para. 25)

Science, technology, engineering, and mathematics propelled the United States into the forefront of the world economy; however, with an increase in teacher accountability, some of the focus involving areas of the STEM innovation is dwindling.

STEM innovation practices have predominantly received attention in the secondary education sector (Murphy & Mancini-Samuelson, 2012). Even though it has been argued, students in the elementary grades are at the best age to become motivated and make connections to STEM fields (DeJarnette, 2012; Ricks, 2011). Many educators are unprepared for teaching STEM, mainly because in STEM education, math and science are not regular math and science, and educators are not receiving necessary professional learning experiences ("Changing mindsets: STEM is not content areas in

isolation," 2015; Ledbetter, 2012). Nadelson and Seifert (2017) agreed on STEM education not being like regular math and science.

> We define integrated STEM as the seamless amalgamation of content and concepts from multiple STEM disciplines. The integration takes place in ways such that knowledge and process of the specific STEM disciplines are considered simultaneously with-out regard to the discipline, but rather in the context of a problem, project, or task. (Nadelson & Seifert, 2017, p. 221)

Elementary educators understand the importance STEM practices have on students' creativity and understanding of real-world problems. They understand students learn and retain information when many parts of the brain are active in activities that encourage movement, talking, and listening (Dodge & Duarte, 2017); however, concerns and needs exist when implementing anything new in their classrooms. This study aims to explore elementary educators' perspectives in implementing the STEM innovation in their classrooms.

Significance for the participants of the study. Implementing something new requires personal change. Educators have to change the way they think about their instructional practices and their role in the classroom (Black et al., 2003). Black et al. (2003) responded, "the way a teacher teaches is inextricably linked with their own personality and identity, ultimately it means changing yourself" (p. 80). Changing a mindset that has developed over the course of many years is challenging; however, encouraging growth within the practice of teaching is an essential factor in implementing change. By participating in this study, elementary educators have the opportunity to provide insight into the STEM implementation process as well as describe overall

strengths and weaknesses involved in the process. Providing focus on the elementary perspective provides an understanding of future elementary implementation and professional learning opportunities associated with the elementary classroom.

Significance for STEM educators. Teaching STEM content provides educators with many challenges and prospects (Abrams, Southerland, & Silva, 2007). Elementary educators routinely use various instructional practices to engage their students; however, learning the best approaches to delivering STEM instructional practices is minimal. Many elementary teaching programs do not convey STEM instructional practices (Fulp, 2002). The lack of preparation leaves many elementary educators feeling unprepared to implement STEM content with fidelity (Bleicher, 2007; Settlage, Southerland, Smith, & Ceglie, 2009). Understanding elementary educators' STEM implementation perspectives can provide other elementary schools considering implementation an educator's understanding of the process, which would be essential when facilitating change towards the STEM innovation.

Definition of Terms

NC STEM Recognition. Accrediation provided by NC STEM Learning Network in collaboration with the NC Science, Mathematics, and Technology Education Center as well as the Friday Institute at North Carolina State University. NC STEM Recognition recognizes STEM schools and programs demonstrating high quality STEM education (Public Schools of North Carolina, n.d.a).

Teacher attitude. Teacher attitude provides the framework for their actions. Expressed through an outward visual appearance as well as their beliefs they express. An attitude constitutes what another individual hears and sees this individual do (de Souza

Barros & Elia, n.d.).

Committee on STEM Education (CoSTEM). CoSTEM includes 13 agencies, including those of the mission-science agencies and the Department of Education. The committee is responsible for improving STEM education in preschool through 12^{th} grade, increase youth engagement in STEM, improve the STEM experience for undergraduate students, work with the underserved, and work on engaging more graduates in the STEM workforce (U.S. Department of Education, n.d.).

Elementary educator. Any individual working in the elementary sector. These individuals include administration, instructional facilitators, teachers, and enhancement teachers.

Engineering education. Teaching the principles and knowledge of engineering practices. In education, the engineering practices involve teaching science, technology, and mathematics in an integrated manner (Successful STEM Education, 2013).

Instructional practices. Particular teaching methods a teacher uses to guide their classroom instruction. Instructional practices involve research-based best practices proven to aid student achievement (Teaching with Primary Sources, n.d.).

Perceptions. Perceptions are the thoughts or pictures teachers have in regard to their students. Formed by life experiences, perceptions provide background knowledge of why a person views or does things they do. It is the lens through which they view different aspects of the world (The Iris Center, n.d.).

Science literacy. The United States National Center for Education Statistics defines science literacy as an understanding of the scientific processes and concepts required in the decision-making process (National Research Council, 1996). A person

who is science literate is someone who

> (1) understands, experiment, and reason as well as interpret scientific facts and their meaning (2) asks, finds, or determines answers to questions derived from curiosity about everyday experiences (3) describes, explains, and predicts natural phenomena (4) reads articles with an understanding of science in the popular press and engage in social conversations about the validity of the conclusions (5) identifies scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed (6) evaluates the quality of scientific information by its source and the methods used to generate it (7) poses and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately. (National Research Council, 1996, p. 22)

Teacher accountability. Teacher's responsibility for the students within their learning environment. Teachers are held responsible for the performance of their students. The No Child Left Behind Act holds schools and the school system accountable for results (Social and Cultural Foundations of American Education/ Accountability/Teachers, n.d.).

Assumptions

According to Foss and Waters (2007), assumptions are placed on a study to guide the research. Simon (2011a) agreed with the assessment of the term; studies have components upon which research is reliant. These assumptions are beyond the control of the researcher (Simon, 2011a). One assumption to consider in this research is the elementary educators participating in the study are implementing STEM instructional practices into their classroom instruction. The three schools involved in the study are

working towards NC STEM Recognition; therefore, it is assumed all members of the school's organization participate in the implementation of the STEM innovation.

Furthermore, the researcher assumes the elementary educators participating in the study responded truthfully to the survey questions. To encourage trust among the participants of the survey, the survey was elective and remained anonymous. Those wishing not to participate in the survey could decline to participate.

Additionally, the researcher assumed the elementary educators participating in the focus group sessions responded truthfully to the interview questions. Those participating in the survey were doing so on a volunteer basis; therefore, the researcher assumed they were eager to share, learn from others, and encouraged by the research being conducted.

Limitations and Delimitations

With any research, limitations and delimitations are part of the process. These influences or choices may affect or restrict the research in some manner. Limitations, as stated by Price and Murnan (2004), are features of the design or methodology of the research that influence the analysis of the discoveries and are beyond the control of the researcher, whereas delimitations are choices made by the researcher that determine the limits of the study (BCPS Independent Research Seminar, n.d.). Delimitations are controlled by the researcher.

Limitations. The limitations of the study might influence the results and therefore should be mentioned. During the study, the researcher conducted research from within the researcher's district among three elementary schools. The elementary schools involved in the study were all at different points in their implementation process and towards NC STEM Recognition certification. Only three elementary schools within the

district are utilizing STEM education; therefore, these three elementary schools were chosen for the study.

Additionally, during the study, surveys were used to collect quantitative data. As a result of this tool, responses made by individuals during the research were outside the control of the researcher. The survey was designed to be responded to once by the participant; therefore, the data measured addressed a single point in time.

Furthermore, a third limitation involved teacher perspectives of implementing STEM instructional strategies at the three area elementary schools. Each of the three elementary schools began the implementation of STEM innovation at different points in time. One school's implementation journey began during the 2013-2014 school year, another began implementation during the 2014-2015 school year, and the third school began implementation during the 2015-2016 school year; therefore, each of the three elementary schools expressed a different need for the STEM innovation and received different amounts of funding, support, and professional learning experiences and each organization's members expressed a different mindset.

The fourth limitation focused on the educators involved in the focus group sessions. The individuals involved in the focus group sessions were doing so as volunteers. Considering that participation was voluntary, the participant sample was outside the control of the research; therefore, the small size of the sample might not express the beliefs of a larger population.

Delimitations. Delimitations in research involve aspects of the research that the researcher chooses. The focus of the research involved elementary educators at three schools within the researcher's district due to convenience; therefore, the study was

limited to elementary educators within one school district located in the Piedmont of North Carolina. The results from the research may not reflect the perspectives of implementing the STEM innovation in other elementary classrooms across the nation. Different results might occur within different school districts.

Additionally, a delimitation involved the three schools within the district. Kroeger (2016) mentioned, "teaching STEM in elementary grades opens the door for teachers and students to become tomorrow's movers and shakers" (para. 4). Additionally, when young students develop a strong basis in STEM, they "play an integral role in our nation's global competitiveness and economic stability" (Kroeger, 2016, para. 4). The three elementary schools are the only elementary schools focusing on STEM innovation. A few secondary schools within the district were also implementing STEM innovation; however, because of their secondary title, they were not included as part of the research. Only elementary schools were chosen based on the implementation of this certain innovation design.

Moreover, another delimitation involved limiting the research to only elementary educators. In limiting the research to elementary educators' perspectives, perspectives of educators within secondary education were not included; therefore, this delimitation narrowed the scope of the research. Also, limiting the research to only elementary educators' perspectives limited the findings to only those with an elementary degree, meaning the perspectives of teacher assistants were not an area of focus. Even though these individuals were also involved in the implementation of the innovation, their perspectives and experiences were not addressed in the study.

Chapter 2: Review of Literature

Introduction

With an increase in high-quality education, many educational intuitions across the nation have turned to implementing the STEM innovation into their instructional practices. With this push, however, many elementary educators feel unprepared to teach science inquiry in a different way (Davis, n.d.). To improve competency, learning about the innovation must occur. Hall and Hord (2015) reiterated, "each change initiative represents a new opportunity to learn … even when there is little improvement there still is learning from experience" (p. 9). In learning about the innovation, educators must discover how STEM education is different from traditional instruction; therefore, the learning that takes place leads to successes and challenges for all educators during the implementation phase.

The literature review focuses on five areas: laws and acts leading to the STEM innovation, perspectives on STEM and STEM integration, STEM instructional practices, successes and challenges in implementing the STEM innovation, and STEM support. Each area of the literature review is constructed through the lens of the postpositivist paradigm and Kurt Lewin's model of organizational change; therefore, the research questions drive the outline of the literature review. However, to understand the STEM innovation, background information concerning its establishment needed to be addressed.

Laws and Acts Leading to STEM Innovation

The pathway of education in the United States is unpredictable. The changing world itself provides educational opportunities educators must develop and support (Thornburg, 2009). Globalization has revolutionized the need for changing educational,

instructional practices (World Assembly of Youth, n.d.). Luo and Matthews (2013) mentioned, "advances in communication and technology now permit the scientific community to share data and publications within minutes" (p. 1). Globalization created technological advances; and the end of trade impediments created nations, businesses, and personal influences to spread around the globe swifter and more cost-efficient than ever before (Stewart, 2012). In 1986, the United States' stance on globalization and its capacity to support innovation led John A. Young to found the Council on Competitiveness (Compete: Council on Competitiveness, 2018). During the Reagan administration, the United States competitiveness became contested by Japan and Germany. The council was formed to structure policy and govern educational programs "to jump-start productivity and grow America's economy" (Compete: Council on Competitiveness, 2018, para. 1).

In 2006, concerned over federal government support as to education in fields involving science, technology, engineering, and mathematics (STEM), President George W. Bush established the American Competitiveness Initiative (Bush, 2006a). The initiative called for an increase in research and development within the physical sciences and an expansion of graduates in postsecondary education systems within STEM fields of study (Bush, 2006a). During the 2006 State of the Union Address, President George W. Bush pronounced,

> One of the great engines of our growing economy is our Nation's capacity to innovate. Through America's investments in science and technology, we have revolutionized our economy and changed the world for the better. Groundbreaking ideas generated by innovative minds in the private and public

> sectors have paid enormous dividends—improving the lives and livelihoods of generations of Americans. (Bush, 2006b, para. 1)

The initiative committed $137 billion to strengthen research, development, and education as well as support free enterprise (Bush, 2006b); however, in 2014, the Level Playing Field Institute (2014) reported, "the World Economic Forum ranks the United States 52nd in the quality of mathematics and science education, and fifth (and declining) in overall global competitiveness" (para. 1).

In 2007, the National Academies of Sciences, National Academies of Engineering, and National Academies of Institute of Medicine published the report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, warning the U.S. of the current weakness of STEM in the educational system. Policymakers acted and in 2007 worked to create the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act (America COMPETES Act) which was signed into law by George W. Bush (National Science Board, National Science Foundation, National Center for Science and Engineering Statistics, 2016). The America COMPETES Act was established to improve the innovation competitiveness of the United States by reinforcing scientific education, improving technological ventures, attracting global leaders of their fields, and providing training in 21st century job skills (Office of the Press Secretary, 2007). The America COMPETES Act also sanctioned STEM education programs at the National Science Foundation and continued to be a focus of the government today (National Science Board, National Science Foundation, National Center for Science and Engineering Statistics, 2016).

In 2009, President Barack Obama propelled Educate to Innovate into focus. The initiative proposed to motivate students within the United States to become leaders in science and math (Obama White House Archives, n.d.). The campaign included efforts from not only the federal government but also efforts from leading businesses and private ventures as well as science and engineering associations to focus on prioritized areas:

> (1) building a CEO-led coalition to leverage the unique capacities of the private sector, (2) preparing 100,000 new and effective STEM teachers over the next decade, (3) showcasing and bolstering federal investment in STEM, and (4) broadening participation to inspire a more diverse STEM talent pool. (Obama White House Archives, n.d., para. 3)

President Obama understood the power educators have in encouraging student success, especially in STEM fields. The Obama White House Archives (n.d.) mentioned President Obama believed educators in STEM fields needed to create experiences for students that supported active learning through the project-based design. This application would encourage students to develop a passion for lifelong learning (Obama White House Archives, n.d.). The initiative also strived to “elevate and engage a talented squad of existing STEM teachers from across the country in the proliferation of best practices and effective professional development” (Obama White House Archives, n.d., para. 13).

In 2010, the America COMPETES Act became reauthorized. The 2010 act increased research investments in the physical sciences, working towards increasing educational prospects in the STEM fields by creating innovation frames and making them a priority (America COMPETES Act, n.d.). The act also approved grant and funding opportunities for higher education institutes that encourage innovation.

Even with all these initiatives and acts in place, few American students are pursuing educational opportunities within the field of STEM (U.S. Department of Education, n.d.). Once the leader in the number of engineer graduates, the United States is now ranked third in the number of college students obtaining a degree within the STEM field (DeJarnette, 2012). In fact, in 2016, China and India produced more STEM graduates than the United States and Europe (McCarthy, 2017). India produced 4.7 million graduates, with China coming closely in second with 2.6 million (World Economic Forum, 2016). The United States is rounding out the top three with only 568,000 graduates (World Economic Forum, 2016). Businesses in the United States within the STEM sector have expressed concern over the number of workers entering the field (Langdon, McKittrick, Beede, Khan, & Doms, 2011). “Over the past 10 years, growth in STEM jobs was three times as fast as growth in non-STEM counterparts” (Langdon et al., 2011, para. 1). Schools themselves began to take notice and started placing STEM education programs at the forefront of their framework for learning and began implementing protocols to assess and validate the quality of their STEM program. NC STEM Recognition procedures were put into place to build knowledge, expectations, and demonstration of STEM standards (Public Schools of North Carolina, n.d.a).

With quality control measures in place to enhance STEM education, some education institutions began to prepare students for global jobs in STEM fields.

Perspectives on STEM Innovation

In the 1990s, the National Science Foundation created the STEM acronym to combine strengths of scientists, technologists, engineers, and mathematicians, in the hope of generating a sounder political voice (STEM Task Force Report, 2014). In 2012, to

increase STEM education, North Carolina state leaders established a plan to ensure students were prepared for 21st century jobs (North Carolina STEM Center, 2018); however, STEM education is only one strategy leaders of North Carolina utilize in the public arena to prepare students for these types of high demand career fields (Public Schools of North Carolina, n.d.a). STEM education, according to the STEM Task Force Report (2014), increases understanding among the four fields based on the incorporation of "real-world, problem-based learning" that connects the fields "through cohesive and active teaching and learning approaches" (p. 9). Public Schools of North Carolina (n.d.b) agreed with this response "to maintain North Carolina's supremacy; future workers must have the STEM skills leading companies demand and the citizenship the 21st Century now requires for success" (p. 2). The North Carolina STEM Center (2018) acknowledged maintaining scientific and technological leadership is vital for the economy, security, and future of the state. Nevertheless, a problematic dispute exists for researchers involved in STEM education, and different explanations of the STEM innovation exist (English, 2016).

In research, the STEM innovation was described many ways (Burke, Francis, & Shanahan, 2014; Honey, Pearson, & Schweingruber, 2014; Moore & Smith, 2014; Rennie, Wallace, & Venville, 2012; Vasquez, 2015; Vasquez, Sneider, & Comer, 2013). North Carolina's definition of the term encompasses an expansive perspective as well: "STEM Education is an infusion of Science, Technology, Engineering, and Mathematics through project-based learning to understand complex problems and to prepare our next generation of innovators" (Public Schools of North Carolina, n.d.c, para. 1). English (2016) wrote the STEM innovation was interdisciplinary; however, this definition also

differed considerably and leads to many interpretations. Given the numerous interpretations concerning the STEM innovation and STEM integration, "it is little wonder that confusion can arise when researchers and policy developers refer to STEM education but differ considerably in their perspectives" (English, 2016, p. 2). Bybee (2013) noted,

> There is an interesting paradox I have observed concerning definitions in education: Many request a definition, and few agree with one when it is presented. So it is with STEM education. The meaning or significance of STEM is not clear and distinct. There is reference to four disciplines, but sometimes the meaning and emphasis only include one discipline. In some cases, the four disciplines are presumed to be separate but equal. Other definitions identify STEM education as an integration of the four disciplines. (p. x)

Brown et al. (2011) as well as Stansbury (2011) acknowledged the absence of a recognized definition could influence teachers' perceptions of the STEM innovation. Nonetheless, whatever definition a nation, state, or school adopts, it is essential to be uniform in attaining the desired goals of the innovation.

STEM education. In North Carolina, STEM education is spotlighted as a means to encourage financial growth and revenue for the state. By the year 2020, there will be roughly 400,000 STEM-related jobs and over 70,000 newly created STEM-related jobs in North Carolina alone (Public Schools of North Carolina, n.d.b). This number indicates a higher growth rate compared to other jobs found in the state (Public Schools of North Carolina, n.d.b). Nevertheless, the North Carolina Commission on Workforce Development (2011) revealed that even during times of high unemployment rates,

businesses reported strain in finding capable workers for jobs located in STEM fields.

Many reasons for the strain in finding capable workers rests in the hands of educational institutions. The U.S. Department of Education (n.d.) reported,

> All young people should be prepared to think deeply and to think well so that they have the chance to become the innovators, educators, researchers, and leaders who can solve the most pressing challenges facing our nation and our world, both today and tomorrow. But, right 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. (para. 3)

Therefore, it becomes the job of the educational institute to provide these opportunities lacking in the learning culture of youth. The elementary institute offers the opportune setting to invest in the STEM foundation (Kroeger, 2016). Elementary students are at the age in which science, technology, engineering, and mathematics combine to play a vital part in the globalization and economic strength of the nation (Kroeger, 2016); however, educators must nurture the critical thinking STEM education provides.

Advocates of STEM education believed four instructional ideologies were needed to encourage critical thinking. According to these ideologies, STEM education should (1) combine technology, (2) be integrated and extend outside STEM fields, (3) connect to the real world, and (4) be grounded in inquiry-based undertakings (Hansen & Gonzalez, 2014; Laboy-Rush, 2011; Lantz, 2009; Sanders, 2009); however, research supporting these ideologies was not equivalent across the principles and was few and far between in the elementary setting (Hansen & Gonzalez, 2014). Nonetheless, research has shown evidence to support these ideologies. Hansen and Gonzalez’s (2014) research showed (1)

substantial knowledge gains in math and science related to combining technologies into the secondary classroom; (2) inquiry-based learning projects conducted in the secondary science classrooms increased positive involvement; (3) real-world learning displayed reasonable positive gains in math secondary classes; and (4) when integrating math in other disciplines, a positive correlation within math was achieved. With these correlations among the four STEM educational ideologies, STEM education can be viewed as the bridge between the math and sciences and globalization of STEM-related fields of study (Engineering for Kids, 2016).

The National Center for the Advancement of STEM Education (2008) supported STEM education's ideology of real-world learning. "Inquiry entails investigation in one or more areas of science, and design relies on engineering principles and practices to devise solutions to real-life problems. In turn, science and engineering depend on mathematics and technology" (National Center for the Advancement of STEM Education, 2008, para. 5). In this perspective, STEM education is an integral part of understanding and explaining solutions to real-world problems (National Center for the Advancement of STEM Education, 2008). Real-world problems allow students to become immersed in an inquiry that is relevant to their lives.

Hands-on learning involving real-world problems in the STEM elementary classroom begins the foundation for the crucial development of promoting a lifelong passion for learning (STEAM Powered Family, 2017). This passion advances creativity in all students, no matter the level of ability, and has become one of the most significant educational concerns of recent years (Preston, 2018). STEAM Powered Family (2017) advocated for implementing the STEM innovation in the elementary classroom: "The

greatest benefit of STEM is that it fosters that love of learning. Instilling that passion and drive to learn that is at it's most crucial stage during the elementary years" (para. 7). During the elementary formative years, students express interest and curiosity and often question why things are the way they are. This natural desire for knowledge encourages exploration and a love for learning that will drive elementary students into their secondary years (STEAM Powered Family, 2017).

President Obama voiced the importance of STEM education and its relevance for the future of the nation and agencies as well as policymakers and continued to prioritize the STEM innovation as a means of increasing globalization among STEM fields. This prioritization can create habits and knowledge that can be integrated, leading to the construction of aptitudes incorporated into real life (Honey, Pearson, & Schweingruber, 2014).

STEM integration. Many elementary educators conversely lack STEM understanding and are uncomfortable implementing the innovation in the classroom (Milgrom-Elcott & Blackwell, 2016). As mentioned previously, many educators implementing the STEM innovation have received little or no professional learning experiences in how to change traditional instructional practices to an integrated instructional approach (Chalmers et al., 2017; "Changing mindsets: STEM is not content areas in isolation," 2015; Ledbetter, 2012). Integration of instructional practices is unfamiliar for many elementary educators who are accustomed to teaching each subject in isolation (Fryer, 2015); however, STEM education is not designed to be taught like traditional subjects are usually taught in elementary school, meaning the STEM innovation is designed to be implemented through integration.

Nadelson and Seifert (2017) mentioned, “The integration takes place in ways such that knowledge and process of the specific STEM disciplines are considered simultaneously without regard to the discipline, but rather in the context of a problem, project, or task” (p. 221). Through the integration of multiple subjects, knowledge learned across topics can be used to formulate and design solutions to different real-world problems (Nadelson & Seifert, 2017). Meaning, in the STEM classroom, there are no designated times for science, technology, engineering, and mathematics as all subjects are taught in an integrated way in which the learning of these subjects takes place throughout the work of the STEM design process; however, this is not the way in which most elementary educators learn to teach.

Educators understand the importance of subject integration, for it is not a new concept; and research has shown the presence of integrated knowledge permitted students to acquire a profound understanding of the STEM principles (Krathwohl, 2002). This concept presented students a prime opportunity to experience learning in real-world context, rather than learning piece by piece (Tsupros, Kohler, & Hallinen, 2009). Despite this understanding and knowledge, adoption of integration is a current event in k-12 education (Honey et al., 2014). The STEM innovation saw many educators nonetheless implementing the innovation in isolation and not through integration (Nadelson & Seifert, 2017). In many instances, this lack of integration was because to integrate subjects, the process can be multifaceted and complicated and was not as simple as incorporating different disciplines together (Wang, Moore, Roehrig, & Park, 2011). Nonetheless, STEM integration consists of integrating science, technology, engineering, and mathematics in which projects and inquiry are related to real-world learning.

Chang and Yang (2014) revealed the STEM innovation was valued in American science education, citing that it features an integrated approach to curriculum design that can be connected to advancement in modern-day science. Lai (2018) acknowledged "classroom discussions and hands-on training in this curriculum allow students to understand conceptual and procedural knowledge and promote teamwork skills and creativity" (p. 112). STEM education emphasizes the development of knowledge, aptitudes, and abilities needed to understand the 21st century (Fan & Yu, 2016). Learning through this approach can encourage students to explore and understand real-world problems, creating problem solvers (Scholastic, n.d.).

Creativity. To encourage and prepare students in the understanding of life skills necessary for the 21st century, educators must foster students' creativity (Henderson, 2008). This creativity sponsorship was supported by the 21st Century Skills, Education & Competitiveness: A Resource and Policy Guide (2008): "Many of the fastest-growing jobs and emerging industries rely on workers' creative capacity—the ability to think unconventionally, question the herd, imagine new scenarios, and produce astonishing work" (p. 10). Americans for the Arts (2017) stated that creative individuals help to strengthen the innovated work needed for the nation to compete globally, and this creativity helps to build and assist in the development of economic vibrancy.

Creativity establishes the innovation needed for the progress and development of the nation and powers the country's economy (Townes, 2016). The word *creativity* lends itself to some interpretations depending on the theory. Piirto (2004) defined creativity as having aptitude "to make something new or novel" (p. 6); however, Beghetto and Kaufman (2009) differentiated between two types of creativity: (1) little-c and (2) big-c.

Little-c creativity depicts creativity within everyday tasks and is open to everyone; big-c creativity represents prominent and groundbreaking creative achievement and is only displayed by a small number of parties (Beghetto & Kaufman, 2009). Nonetheless, creativity is something many schools across the nation are lacking. Many educators focus on high-stakes test scores and memorization and place creativity as a less immediate concern (Townes, 2016); however, in today's society, the creative thinker is a vital part of the global market and students need to become active learners in a way that connects them to real-world problems (Ramirez, 2013a).

Researchers believe creativity is fundamental to the nation's economic future and government leaders are beginning to take notice (Sharp & Le Métais, 2000, p. 3). Some educational institutions are also observing this need and are beginning to change practices to address it. STEM professionals also argued for creativity, citing success in the field requires one to use their imagination in the construction of models and/or prototypes (Root-Bernstein, 2015). One of these professionals, Ramirez (2013b) mentioned, "from my vantage as a scientist, one of the best ways to encourage creativity and curiosity is by improving [STEM]. STEM requires creativity to discover new things and stokes the fires of curiosity with one question leading to another" (para. 5); therefore, it takes a creative individual to look at resources and imagine a way in which the tools can work together to solve a real-world problem.

Innovation in the classroom. Innovation is an approach to academic learning that focuses on cultivating a student's creative self-confidence through an application of active learning that fosters inquiry (Kwek, 2011). Meanwhile, few schools implement innovation and allow students to take control of their education. This lack of

implementation could be attributed to educational mandates in which policy stipulates increased academic performance based on high-stakes test scores. The consequence of high-stakes testing is one in which educators focus on test preparation, therefore narrowing the curriculum and instruction taught (Herman, 2004); however, these policies do not mean the end of innovation in the classroom, and schools can once again "give voice" to their students.

According to Pink (2005), 21st century learning will be directed by a different type of knowing, which was also supported by Gardner (2010) who emphasized students of the future must develop "a robust temperament, and a personality that is unafraid of assuming reasonable risks" (p. 28), both cognitively and physically early in their life (p. 28). This outlook stressed that change was needed in traditional instructional practices. This is further supported by Jacobs (2010) who pointed out not only should curriculum focus on the development and construction of new information, but it should also focus on the cultivation of a society that encourages creative thinkers. To meet these prospects, traditional curriculum needs to integrate academic content as well as innovation (Kwek, 2011). "This means spending less time explaining through instruction and investing more time in experimental and error-tolerant modes of engagement" (Kwek, 2011, p. 3). The STEM innovation stresses this innovated active learning design, encouraging interest and critical thinking in solving real-world problems relevant to the life of the student (Roland, 2017).

Curriculum that supports innovation encourages creative self-confidence; and by implementing it into instructional practices, the educator moves from a more traditional learning approach to one that endorses creativity and encourages critical thinking and

problem-solving (Barseghian, 2009). Integrating the STEM innovation into the curriculum provides students with an innovated design that displays the importance of inquiry (Roland, 2017). This type of innovated practice allows for problem-based and project-based learning that is related to the real world. Steinberg (1998) supported innovated design as a process in which the student does not only take in information but experiences active learning.

STEM Instructional Practices

Bybee (2010) established the first step in improving STEM education: Integration rests in the understanding of STEM literacy and establishing it within the classroom. STEM literacy, as defined by Bybee (2010), involves the combination of the STEM ideologies and four interconnected workings involving (1) obtaining knowledge and understanding of science, technology, engineering, and mathematics as well as applying this knowledge; (2) grasping the understanding of inquiry, design, and analysis; (3) identifying how the STEM ideologies shape our understanding of the world; and (4) involving STEM in the understanding of real-world issues that affect each citizen.

Educational literature supports increasing efforts to include the STEM concept, though there are diverse views on effective STEM instructional practices. In 2007, the United States Department of Education released the *Report of Academic Competitiveness Council*, which established that "despite decades of significant federal investment in science and math education, there is a general dearth of evidence of effective practices in STEM education" (p. 3). Stone (2011) supported this shortage in evidence, concluding more research needed to be conducted into effectively integrating STEM instructional practices.

Marzano, Pickering, and Pollock (2001), Reigeluth (2013), and Smith, Rayfield, and McKim (2015) concluded successful instruction depends on the use of lucrative instructional methods. These methods are one of the primary principles in determining student knowledge (Marzano et al., 2001). Regarding the STEM innovation, certain instructional practices have been considered, but little is known of the effectiveness of these strategies (Rosicka, 2016). With this said, an integration of a few research-based instructional practices can be expanded to encourage student understanding and knowledge of STEM literacy (Vega, 2012). These instructional practices include (1) inquiry-based learning through a real-world application, (2) the application of knowledge through the engineering design process, and (3) active learning.

Inquiry-based learning. Victoria University (2015) acknowledged inquiry-based learning necessitates direction from the educator as a facilitator to provide the construction of knowledge for their students. This type of learning enables educators to scaffold support and build upon student knowledge "from a natural process of inquiry in which students experience a 'need to know' that motivates and deepens learning" (Rosicka, 2016, p. 8). Instead of lecturing, inquiry-based learning requires students to perform investigations in reaching a solution that is supported through research (Center for Inspired Teaching, 2008). This approach to learning allowed educators to develop the knowledge students express in problem-solving and critical thinking. In this environment, learning becomes student led and knowledge becomes ingrained, allowing real-world inquiry forefront in the decision-making process that could affect the life of a student (Center for Inspired Teaching, 2008).

In the book *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to*

Achievement, Hattie (2009) used the phrase inquiry-based teaching rather than inquiry-based learning and referred to it as,

> the art of developing challenging situations in which students are asked to observe and question phenomena; pose explanations of what they observe; devise and conduct experiments in which data are collected to support or contradict their theories; analyze data; draw conclusions from experimental data; design and build models; or any combination of these. Such learning situations are meant to be open-ended in that they do a not aim to achieve a single "right" answer for a particular question being addressed, but rather involve students more in the process of observing, posing questions, engaging in experimentation or exploration, and learning to analyze and reason. (pp. 208-209)

Bybee (2010) mentioned in STEM education, technology and engineering should be integrated in the science and mathematics disciplines; however, "the scale at which they are in schools is generally quite low" (p. 30) and instead they were treated as isolated disciplines. Promotion of this STEM instructional practice, according to Barry (2014), Chang and Yang (2014), Cheng, Yang, Chang, and Kuo (2016), and Lai and Sheu (2016), should be used to engage students in technology examination to strengthen the STEM instruction which advances STEM literacy.

When educators incorporate challenge through inquiry-based teaching, students develop science literacy that engages them to investigate and evaluate scientifically (Bulba, 2015); thus, "scientific inquiry requires the use of evidence, logic, and imagination in developing explanations about the natural world" (Newman, Abell, Hubbard, McDonald, Otaala, & Martini, 2004, p. 258), drawing a connection between

scientific and classroom inquiry. According to the National Research Council (1996), inquiry-based practices create learners who (1) are "engaged by scientifically oriented questions," (2) give a "priority to evidence," (3) expresses "explanations from evidence," (4) assess "explanations in light of alternative explanations," and (5) "communicates and justifies proposed explanations" (p. 25). Keys and Bryan (2001) agreed with the National Research Council's description of inquiry-based practices, by acknowledging that inquiry-based practices do not encompass a specific instructional practice, but they do create practices that are desirable because they "paint a rich picture of meaningful learning in diverse situations" (p. 632). Supported by the STEM innovation, two types of inquiry-based practices include problem-based learning and/or project-based learning.

Highly recommended by the National Science Education Standards, both types of inquiry-based learning enable students to become scientists, thus allowing them to discover information in a student-centered environment (Meyrick, 2011). "Not only are critical thinking and reasoning skills explicitly taught using the scientific inquiry process, but students also personify what it is like to research, test, discover, and think like a scientist" (Meyrick, 2011, para. 9).

Problem-based learning. In problem-based learning students discover by solving problems related to real-world occurrences (Barrows, 1996; Kumar, 2010). The problem-based learning approach to learning requires the student to self-direct their learning, and the educator's role is that of the facilitator (Barrows, 1996; Kumar, 2010). Schmidt (1993) cited the groundwork of problem-based learning consists of enabling prior knowledge that is needed to process and understand new information, the creation of teamwork in which conversations and a group dynamic is needed to process and analyze

information, and context paralleled to that of real-world situations that encourage learners to gain knowledge through relevant understanding. The characteristics of problem-based learning will differ depending on the subject matter; however, there are some features that are common: (1) the problem must inspire the learner to seek out a profound understanding of the concept in question, (2) the problem should require the learner to make a sound decision based on the information given and defend the decision, (3) the problem should consist of *knowledge* that be integrated around multiple disciplines, (4) the problem must ensure different perspectives can be heard when working in a group context, and (5) the problem should engage students in the learning process (Duch, Groh, & Allen, 2001). Through the problem-based learning instructional practice, students improve their understanding of problem-solving, research, and social skills (University of Delaware, n.d.). These understandings lead students to become motivated to learn, think critically, develop communication skills while working cooperatively, retain information, and cultivate a passion for learning (University of Delaware, n.d.).

***Project-based learning*.** Whereas problem-based learning is student-centered and creates opportunities in which students learn through solving problems in a group dynamic where oftentimes there is more than one correct answer or way to solve a problem, project-based learning is an approach to inquiry learning in which goals are set and structured (Campbell, 2014). Problem-based learning usually consists of a real-world scenario and is constructed within a single subject; however, *knowledge* of multiple disciplines is needed to solve the problem. Project-based learning consists of a real-world problem that is multidisciplinary and takes time to solve (Campbell, 2014). It began in 1918 with the work of John Dewey and William Kilpatrick and consisted of an

inquiry-oriented approach in which investigation occurred around the construct of a complex question or challenge (Campbell, 2014). Project-based learning promotes student engagement and active learning by requiring students to think critically about the work they are accomplishing (Campbell, 2014; Savery, 2006). While both project-based learning and problem-based learning have slight differences they, both promote the 21st century skills needed in the STEM classroom as well as produce active learning (Campbell, 2014).

Engineering design process. In 1973, Dr. Bernard Roth shaped a paper documenting an innovative way to describe the "design process." He defined engineers may oftentimes find solutions to problems quickly, simply to find improved clarifications after further thought (Roth, 1973). In the paper, Dr. Roth described a design process, recounting how engineers effectively go through a sequence of steps to think critically about a problem. As a result of these steps, different solutions to the problem could be formulated. He described the design process as a sequence of events through which a design passed before it was accomplished. "By making this a conscious process, the engineer can greatly improve his chances of arriving at a better solution" (Roth, 1973, p. 4). This paper was the beginning phase of the engineering design process, in which a series is followed to solve a problem (Science Buddies, 2018). In the engineering design process, also known as EDP, students are introduced to the concept of engineering and how it relates to math and science. The process allows students to become engaged in the STEM innovation, relating how engineers apply knowledge to solve problems (Hill-Cunningham, Mott, & Hunt, 2018). Figure 2 describes the EDP.

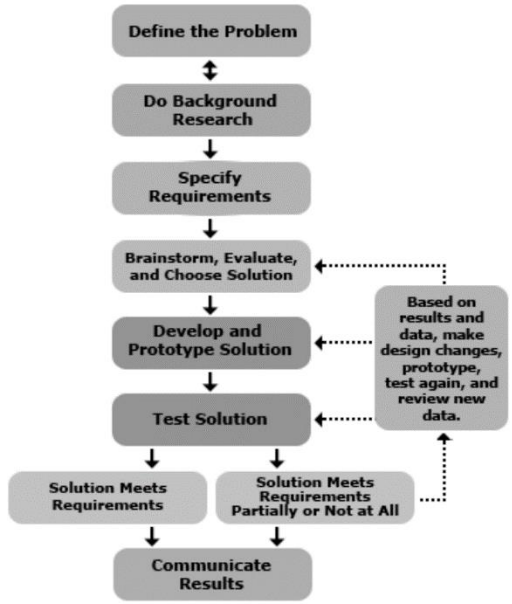


Figure 2. The Engineering Design Process model. This figure provides a visual model of the engineering design process and the sequence of steps engineers take to construct possible solutions to problems (Science Buddies, 2018).

In the first step of the design process, the learner *defines the problem*. This step provides the reference point in answering real-world inquiry and requires the learner to ask specific questions to begin their work: (a) What is the problem, or what needs to be solved, (b) Who is experiencing the problem or need, and (c) Why is it pertinent to solve the problem or need (Science Buddies, 2018). The second step of the design process, *do background research*, requires the student to learn from others. In this step students, research current solutions to comparable problems and, in planning for the design, try to prevent mistakes that were made previously (Science Buddies, 2018). In the research, learners are required to interview the current customer or gather as much information as possible about the problem before the design of the solution occurs. The third step of the EDP specifies the requirements (limitations and delimitations) the solution must express

in order to succeed in the necessary specifications required of the client or problem (Science Buddies, 2018). Next, the learner *brainstorms solutions*. When designing solutions to a problem, there are many possibilities in how it can be solved. In this step, team members collaborate the possibilities of solving the problem based on the limitations or delimitations required. The collaboration process of this step allows for different perspectives to be heard: "If you focus on just one [solution] before looking at the alternatives, it is almost certain that you are overlooking a better solution. Good designers try to generate as many possible solutions as they can before beginning the design process" (Science Buddies, 2018, para. 6). Within the fourth step, learners also choose the best solution for the problem based on feedback from team members. Through the collaborative process, members will observe to determine if certain solutions will meet limitations and delimitations of the requirement more than others (Science Buddies, 2018). In the fifth step, the hands-on engineering aspect of the work begins with the building of a prototype. The first prototype is often constructed with various materials, compared to the materials used in the final product, and is a rough design (Science Buddies, 2018). These prototypes "are a key step in the development of a final solution, allowing the designer to test how the solution will work" (Science Buddies, 2018, para. 9). After building the prototype, the learner tests the design and notes any flaws in the original design. This step allows the learner to learn from their mistakes and consider different solutions in how to solve the problem. Once tests of the prototype have occurred and notes are made, redesign occurs. The redesign incorporates the notes for improvement to construct a new prototype that considers the feedback learned (Science Buddies, 2018). Once a new prototype is designed, the EDP requires a test to be

performed. During this process, refinements to the prototype may be observed and future prototypes may be required as well as additional tests. Once a final prototype has been developed that meets all of the clients' or problems' specifications, the learner is required to communicate the results just as professional engineers would be required to do (Science Buddies, 2018).

The EDP can be reformulated based on the needs of the educational institution and can be redesigned for their use; however, the basic principles of the EDP still exist in that the learner will (a) define the problem; (b) conduct research; (c) brainstorm possible solutions; (d) build prototype based on research and specifications; (e) test prototype and make notes of changes; (f) review, redesign, and retest prototype; (g) communicate final results.

Active learning. As mentioned previously, the STEM innovation was designed to be interdisciplinary; therefore, problem-based and project-based learning were designed around this theme. Active learning is a component of problem-based learning and EDP. Rosicka (2016) defined active learning as using multiple intelligences (discussion, collaboration, critical thinking, problem-solving, and connection) to solve real-world problems and learn from these encounters. In active learning, students are responsible for their learning (Sirinterlikci, Zane, & Sirinterlikci, 2009). Students learn to develop their own knowledge and begin to nurture intellect surrounding the importance of deducing and analyzing, like a scientist (Rockland et al., 2010). Similarly, students use engineering to be active learners. These engineering concepts are needed to assume globalization responsibilities using real-world problems (Meyrick, 2011).

Analysis of literature, as referenced by Bonwell and Eison (1991), suggested

students must go beyond the sense of hearing to retain knowledge; they must be active in their reading, writing, and conversations to become fully engaged problem solvers. Prince (2004) agreed with this proclamation, announcing when educators implement these instructional practices, students become energetic in their own learning. Research suggested that when STEM educators begin to change their traditional instructional practices to active learning, the benefits are elevated (Freeman et al., 2014).

When faced with the requirements of STEM education, many educators are nervous to step away from traditional instructional practices (Blowers, 2017). The reality is that active learning allows for flexibility in which group collaboration can increase student engagement. Blowers (2017) wrote that when educators begin active learning, students begin interaction with peers, allowing the educator to "circulate, listen to conversations, and adjust the content *in which* we present in real time based on students' thinking and questions" (para. 4). Additionally, students who encounter active learning are provided an environment to work through problems collaboratively, which leads to improving social experiences outside of class (Blowers, 2017). In addition, Meyrick (2011) approved this thought describing active learning, involving STEM education, as instructional practice students need to become 21st century learners.

Next generation science standards. Often, educators are held accountable for state testing. This accountability has shifted educator focus to "teaching to the test" and has altered how educators view inquiry-based learning. The National Science Teachers Association (2014) supported this declaration, asserting, "Often, students can answer specific questions about concepts they covered in class, but can't translate that knowledge in applied situations" (para. 2). The National Research Council of the

National Academies (n.d.) affirmed this perspective stating that many students are unable to translate learned knowledge into a deep understanding of the concept along with an explanation sustained by evidence-based opinions and interpretations. To eliminate educator habit of "teaching to the test," the Next Generation Science Standards were fashioned (National Science Teachers Association, 2014). These standards "shift the focus from merely memorizing scientific facts to actually doing science-so students spend more time posing questions and discovering the answers for themselves" (National Science Teachers Association, 2014, para. 1).

There are three elements within the Next Generation Science Standards that combine to form each performance prospect; crosscutting concepts, science and engineering practices, and core ideas. These elements work collectively to support that science learners "build a cohesive understanding of science over time" (Next Generation Science Standards, n.d., para. 1). Crosscutting concepts encourage students to investigate the four domains of science (physical science, life science, earth and space science, and engineering design). When crosscutting concepts are explored and learned in the real-world environment, learning is made clear for students and assists them in developing a coherent understanding of the world in which they are a part (Next Generation Science Standards, n.d.). Science and engineering practices illustrate what scientists do to examine the world around them and what engineers do to construct their interpretation of a solution to a manufactured challenge (Next Generation Science Standards, n.d.). These practices function to help students become active in the learning process and connect in practices that expand their foundational knowledge (Next Generation Science Standards, n.d.). Core ideas are key science concepts that explore the connection between the four

domains of science and the engineering design practices, allowing students to build upon knowledge through their years of learning (Next Generation Science Standards, n.d.).

Each of the three elements mutually work to create science standards that are high-quality based and rich in an active learning approach, encouraging growth and understanding of inquiry-based learning throughout the educational lives and professional careers of all learners (Next Generation Science Standards, n.d.).

Successes and Challenges in Implementing STEM Innovation

To assist in the successful implementation of an innovation, many organizations turn to Kurt Lewin's model of organization change (unfreezing, changing, and refreezing). When moving forward with the implementation of an innovation, the future success depends on the vision of increasing high-quality learning (Hall & Hord, 2015; Hussain et al., 2016). "Developing, articulating, and communicating a shared vision of the intended change" (Hall & Hord, 2015, p. 31) is the first step in moving forward with a change in innovation. Often, this shared vision of change develops through the combined efforts in the creation of the school's mission and vision statements. Hall and Hord (2015) communicated that when implementers encourage a shared vision, support for the innovation can be distributed and planning for the innovation can begin.

The STEM innovation depends on this shared vision of support. STEM education involves learning that can impart a desire for inquiry and innovation in students (Bailey, Kaufman, & Subotic, 2015; Betrus, 2015). It fosters talents such as perseverance, group cooperation, and the diligence of applying learned knowledge to real-world situations (Bailey et al., 2015; Betrus, 2015). Dweck, Walton, and Cohen (2014) contended the STEM innovation develops growth mindsets and behaviors that instill lifelong learning in

a world that is changing daily. *STEM 2026: A Vision for Innovation in STEM Education* (2016) suggested STEM education "is culturally responsive, employs problem- and inquiry-based approaches, and engages students in hands-on activities that offer opportunities to interact with STEM professionals" (p. 1). Unfortunately, developing STEM teaching and learning practices is not universal, and barriers persist throughout the education system (U.S. Department of Education, Office of Innovation and Improvement, 2016).

Our nation's leaders continue to be apprehensive about producing sufficient graduates entering STEM fields and continue to initiate acts to improve education curriculum, most notably to maintain their ability as an influential player in the globalized economy (Connors-Kellgren, Parker, Blustein, & Barnett, 2016). As a result, legislation has increased funding and encourages students to pursue higher learning in careers in the STEM field. Despite this stance, elementary schools often lack funding, professional learning experiences, resources, and support needed to develop the STEM innovation successfully (Office of Innovation and Improvement, n.d.). Even though these barriers in implementing the STEM innovation exist, schools are implementing the innovation to engage young minds and develop a love of learning. The research that follows focuses on successes and challenges associated with implementing the STEM innovation.

Funding. Over the years, there have been many individuals and groups calling for reform of the STEM innovation (Dancy & Henderson, 2008). With the release of the 2007 National Science Foundation Report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, efforts have been made to

expand the number of STEM graduates and raise STEM literacy (Charette, 2012). Federal support for this endeavor can be found through acts, but it can also be found in financial areas.

Funding for the STEM innovation has increased substantially over the last decade. In 2009, the Obama administration provided $260 million to fund the initiative to increase American students’ achievement in math and science (The White House: Office of the Press Secretary, 2009; Charette, 2012). Moreover, in 2017, the Trump administration provided steady funding for the innovation. Unfortunately, the “Department of Education grant program dedicated to STEM has been replaced with a broader state grant program that is receiving less than a quarter of the funding authorized in the Every Student Succeeds Act” (American Institutes of Physics, 2017, para. 1).

Even with the increase in funding, laws allow various organizations to handle the proposed allotted money in various ways (Iversen, 2017). Directed to three segments of Every Student Succeeds Act and The Carl D. Perkins Careers and Technical Education Act, funding for the STEM innovation was received (Iversen, 2017). Every Student Succeeds Act allotted the money to Title I (improving essential programs operated by the state and local governments), Title II part A (supporting operational training), and Title IV part A (grants) and part B (community learning centers); therefore, the allotted funds maintain more than just the STEM initiative.

Even with these allotments, federal funds are available for STEM education. The Department of Education requested states use federal money to increase the STEM innovation for students of lower economic demographics and those who are underserved in the area, specifically females and students of color (Camera, 2016). The federal

government urged states to use the allocated money to purchase materials and devices and train educators in using the STEM innovation (Camera, 2016); however, the federal government noted many states do not disperse funds equally across the state. A report conducted by the U.S. Department of Education (2011) found districts functioning in low economic demographic areas are not receiving comparable funds to other districts across the nation. John King, the Secretary of Education from 2016-2017, established these findings also. In an article written by Camera (2016), Mr. King stated,

> Too often many of our students, especially those who are most vulnerable, do not have equitable access to high-quality STEM and computer science opportunities, which are part of a well-rounded education and can change the course of a child's life. (para. 2)

The lack of federal dollars left many schools in a state of unknown (Solochek, 2012). Educating students in STEM comes with a price tag, and locating the necessary funds for implementing the STEM innovation has left many schools searching for other avenues to provide the necessary funding (Solochek, 2012). To accommodate the push for the STEM innovation, many schools have begun transferring resources, locating public businesses interested in funding the innovation, and applying for private and federal grants (Solochek, 2012). For many teachers, however, applying for grants is a time-sensitive issue. Applying for grants and waiting for decisions can take over a year for some (Fritz, 2018). Even though educators found grants to be a source of providing students with resources their districts cannot provide, many do not apply because of the high competitiveness (Education World, n.d.).

With the limited amount of money available from both public and private

funding, many schools do not acquire the necessary funds needed to create the type of STEM environment needed (STEMSchool, 2017); therefore, schools also do not hire the qualified staff needed, nor do they have the technology or resources needed to stay up to date. STEMSchool (2017) remarked,

> Offering STEM education can be expensive to schools. Hiring professionals that have been trained to teach these subjects can be an added expense that STEM schools cannot take on easily. Many teachers can teach one of the four subjects, a handful can teach two, but very few are qualified to teach all four. (para. 5)

Therefore, to become a STEM school, schools choose to do so and work towards NC STEM Recognition and accreditation knowing that funding the innovation will be a challenge.

Professional learning. In the elementary setting, the STEM innovation is becoming more customary; however, how the educator comprehends, conceptualizes, and interconnects the content of the innovation influences the learning capabilities of students (Diefes-Dux, 2014; Estapa & Tank, 2017). Ejiwale (2013) explained that the principle of educating students in STEM instruction lies in preparing them for future employment within the real world. Preparing them for this future, however, has been met with barriers. "There is growing concern that the United States is not preparing a sufficient number of students, teachers, and professionals in the areas of science, technology, engineering, and mathematics" (Ejiwale, 2013, p. 64). Lack of professional learning opportunities resulted in educators being unprepared to implement the STEM innovation. When implementing any innovation, educators need knowledgeable occurrences to prepare for the innovation and become inspired themselves (Boyle et al., 2013). Hall and

Hord (2015) noted, “The key organizational unit for making change successful is the school. The school’s staff and its leaders will make or break any change effort, regardless of whether the change is initiated from the inside or outside” (p. 12). Educators who have fewer experiences with the innovation may struggle with implementation (Boyle et al., 2013).

Continuous professional development is needed for educators to continue to learn and improve in their instructional practices (Western Governors University, 2017). Professional development, however, is outdated and many educational institutions are implementing professional learning instead. Even though many educators do not know the name has changed, the idea behind professional learning has. Professional learning reflects the concept of active learning (Western Governors University, 2017). Just as the STEM innovation endorses active learning to engage creativity and innovation in students, professional learning engages educators through the application of knowledge and not through lecturing (Western Governors University, 2017). Hall and Hord (2015) pointed out that professional learning is a significant piece of the process needed for the implementation of the innovation to become successful. Through these professional learning opportunities, educators shape their understanding of STEM content and construct a “culture of STEM education at the school” (Office of Innovation and Improvement, n.d., para. 5).

There is literature connecting professional learning and an educator’s sense of self-efficacy. Bray-Clark and Bates (2003) wrote education reform presented challenges for educators and “more challenging standards, high stakes testing, and school accountability are all pressuring administrators to highlight the key linkage between

teacher effectiveness and student achievement" (p. 13), leading educators to renew their attention to high-quality professional learning opportunities to improve instructional practices (Bray-Clark & Bates, 2003).

Regarding science inquiry-based instruction, educators felt unprepared to implement the innovation due to a lack of confidence (Williams, 2016). This lack of confidence was partially due to a deficit in quality adult educational experiences, though those who participated in professional learning experiences sustained confidence in implementing the innovation (Williams, 2016). STEM-based professional learning experiences that provide job-embedded learning focusing on increasing the quality of work offered to students increased implementation at the individual level (NSTA, 2012). STEM professional learning experiences give elementary educators "the competence, confidence, and comfort of being able to teach STEM to their students. In other words, giving them experiences that help them overcome any concerns or anxiety that they have toward STEM" (NSTA, 2012, para. 3), equipping them with the tools needed for implementing the STEM innovation. Unfortunately, the quality of professional learning available to prepare educators in STEM education was weak (Ejiwale, 2013).

Posamentier and Maeroff (2011) documented that it matters who teaches the STEM innovation, and elementary educators are minimally prepared to implement the innovation. Being equipped with content understanding and academic knowledge of best instructional practices to use in teaching are two characteristics educators need to implement the STEM innovation effectively (Ejiwale, 2013). Unfortunately, most graduates who acquire these skills are entering careers involving STEM fields instead of entering the teaching profession (Ejiwale, 2013).

Mindset. Restructuring curriculum to include one that is STEM integrated requires effort from the educator. Additionally, positive attitudes and a willingness to shift current instructional strategies beyond a single subject is crucial for the success of implementation (Al Salami, Makela, & de Miranda, 2017). Glickman, Gordon, and Ross-Gordon (2018) specified some educators "have greater capacities than others to adapt to or change the classroom and school environment" (p. 64). These educators display the growth mindset needed to expand and develop their understanding of the STEM innovation.

The advancement of the term mindset developed from the work of Carol Dweck. Her work established why some individuals achieve their potential and others do not. She found it was not an ability that influenced individuals, it was whether the individual examined the ability as inborn or something that needed to developed (Dweck, 2006). From this research, the two mindsets were established, the fixed mindset and the growth mindset. The fixed mindset became the label for those who believe their intelligence is set and not something that can be developed. On the other hand, the growth mindset is expressed in those who believe effort can alter their intelligence and they thrive on the challenge (Dweck, 2006). Educators encourage their students to become lifelong learners and to display the growth mindset when learning something new. Educators themselves sometimes do not display this philosophy.

The educator's mindset influences the quality in which they view and participate in the implementation of the innovation (Glickman et al., 2018). If educators comprehend the innovation and grasp the advantages associated with the innovation, their motivation to implement the innovation develops (Glickman et al., 2018). To encourage

this mindset, educators must have an active role in the change process, and the school's culture can influence this outlook (Dancy & Henderson, 2008; Hall & Hord, 2015).

Gruenert and Whitaker (2015) noted the school's vision could impact and change the culture of the organization; and with the school's culture providing the framework for deciphering problems, implementation is affected. For an organization, the culture provides the ideals and principles of those in the organization, and these values and beliefs affect whether implementation of the innovation can occur successfully (Glickman et al., 2018; Gruenert & Whitaker, 2015; Hall & Hord, 2015); however, each person is responsible for their mindset and being closed off to new ideas can influence how an individual implements the innovation (Dweck, 2006). If an individual displays negative emotion with the innovation, this can lead to a lack of understanding and an unwillingness to participate in the innovation (Dweck, 2006; Hall & Hord, 2015); however, if an individual displays positive emotion towards the innovation, understanding and learning can occur and can begin to affect the mindsets of others.

Support for STEM. "Change is one of the few constants in our world" (Hall & Hord, 2015, p. viii). Brought forth by policy or personal decision, educators can expect changes to impact classroom instructional practices, and each change idea signifies an opportunity to acquire new understanding. Many individuals outside education, however, desire immediate results and do not allow the implementation to become fully operational. Hall and Hord (2015) argued that for implementation to become fully operational in the educational setting, 3-5 years is needed; therefore, "change is a process and not an event" (Hall & Hord, 2015, p. 10). Time and planning are needed to learn about the innovation as well as necessary support systems to encourage change.

Unfortunately, no matter how lucrative an innovation has been, a collaborative culture, which is cooperative, must exist for impact of innovation (Glickman et al., 2018; Hall & Hord, 2015).

Initial training in the implementation of an innovation, according to Glickman et al. (2018), is essential but is never enough. Support for the innovation is needed early on to escalate the likelihood of success. A study conducted by the Education Alliance at Brown University stated when support for an innovative practice is given, improved performance with the innovation occurs (Unger et al., 2008). This support displays cohesiveness for the expectations and provides resources educators need.

Support for the STEM innovation can be found internally and externally. Internally, the organization can display support through the growth mindset of those implementing the innovation, but support can also be found with school leaders. Ejiwale (2013) pointed out, “it is important to ensure that education leaders are knowledgeable about STEM education so as to cultivate rich STEM learning experiences and expertise in their schools” (p. 67). Hall and Hord (2015) agreed with this outlook; without this support, the innovation can weaken and collapse. Therefore, this leadership is fundamental to the long-term success of the innovation.

Along with school leaders, district leader support can also impact the achievement of an innovation. Creating change requires a team effort, and district support potentially can influence what happens at the school site and with individual users of the innovation (Hall & Hord, 2015). Everyone has a role to play in changing the school structure to one that supports the innovation; without it, the full operation of the innovation will suffer (Hall & Hord, 2015).

Organizational change theory dictates support for change must be supplemented by a certain amount of influence, even when implementors are dedicated to the innovation (Fullan, 2002; Glickman et al., 2018; Hussain et al., 2016). If school leadership or district leaders are unable to sustain their dedication to and influence of the implementation of the innovation, engagement and support will likely cease (Hall & Hord, 2015).

Community support for the STEM innovation also contributes to the success of the STEM education. Gerald Solomon and Ron Ottinger, co-chairs of STEM Funders Network, stated "there is a need for everyone committed to STEM education to come together. Our students need to experience STEM learning in a coherent and connected way" (as cited in Office of Innovation and Improvement, 2015, para. 3). Community support of the innovation encourages these experiences for students and provides educators with the support needed to fund and develop the innovation. A report by the NC STEM Community Collaborative with N.C. Department of Public Instruction declared community support for the sustainability of the innovation is crucial (Carraway, Rectanus, & Ezzel, 2012). The partnership between the school and the community allows for collaboration of where the community and school are headed and encourages growth together.

As mentioned previously, change is a team effort; therefore, no school implements an innovation alone. There are support systems that can be put into place to encourage the success of an innovation. Policies and mandates encourage innovation adoption, but it is the individual who determines if the implementation will occur or not in their classroom. These support systems create opportunities to drive the innovation

forward.

Chapter 3: Methodology

Introduction and Restatement of the Problem

STEM education continues to be a much-discussed topic, for it is considered the means for improving the nation's competitiveness (Brophy et al., 2008; Congressional Research Service, 2006; Ehrlich, 2007; National Science Board, 2007). Many congressional laws have mandated reform of the traditional educational system urging greater support for innovation and the improved quality of instruction; therefore, many specialized educational institutions are emerging, emphasizing connections between active learning and real-world issues provided through the STEM innovation. However, many elementary schools do not utilize the STEM innovation and the benefits it provides, even though research indicated science literacy starts in early childhood (Cafarella et al., 2017; Worth, 2010). Supporters of STEM in the elementary setting acknowledged science literacy takes time and recognized time is not provided adequately (Cafarella et al., 2017). Blank (2013) admitted time provided for science instruction in the elementary classroom is actually decreasing, which was supported by the 2012 National Survey of Science and Mathematics Education Report (2013).

To encourage science instruction, experts in education promoted implementing STEM instructional practices (Chalmers et al., 2017); however, the STEM innovation is unlike traditional instruction and is meant to be taught interdisciplinary and not in subject isolation (U.S. Department of Education & American Institutes for Research [AIR], 2016). For many educators, the traditional instruction received as a child influences their instructional practices, and this practice has led educators themselves to teach in isolation (Fryer, 2015). Additionally, elementary educators have expressed feeling inadequately

prepared for the interdisciplinary instructional practices the STEM innovation needs (Epstein & Miller, 2011). This lack of confidence has led many educators to be unable to shift their mindset to one understanding the STEM innovation (Epstein & Miller, 2011; Marx & Harris, 2006).

Many reasons for the lack of successful implementation exist; however, studies suggested educator perceptions and beliefs influenced whether change initiatives were successful or not (Epstein & Miller, 2011, Milgrom-Elcott & Blackwell, 2016, Talley, 2017). Through a postpositivist paradigm, explanatory sequential mixed methods design, this research investigated the implementation of the STEM innovation inside three demographically diverse district elementary schools to examine elementary educator perceptions and understandings, including strengths and challenges associated with implementation of the innovation. The study also gathered information concerning to what extent elementary educators were supported through the implementation process as well as how the innovation could have been supported in the elementary classroom to make the process flow smoothly.

Review of Research Questions

The five research questions that drove the focus of this study were

1. How can elementary educators' perceptions and understandings of the STEM innovation be described?
2. To what extent are STEM instructional practices being implemented?
3. How do elementary educators characterize successes and challenges in implementing the STEM innovation?
4. To what extent are elementary educators supported in their implementation of

the STEM innovation?

5. How could the STEM innovation be further supported in the elementary classroom?

Setting

Setting of district. The district in which the research was conducted consisted of a demographically diverse area in North Carolina. At the time of the study, farming was the foremost source of income for many of its citizens, with dairy farming popular in the northern and southern ends of the county (Wikipedia, 2018); however, farming in the southern end was decreasing due to industrial development and the vast popularity of a significant high-end water area (Wikipedia, 2018). Therefore, the northern end of the county preserved much of its rural appeal, but the southern end was experiencing swift suburbanization. The county itself included two different school systems, with the district involved in the research divided into five parts.

Ranked among the 20 biggest school districts in North Carolina, the district served more than 20,000 students and is ranked among the top 25% of school districts in the state (District Website, 2018). At the time of the study, the district had 36 schools consisting of 17 elementary schools, 10 middle schools, nine high schools, and one alternative school. The district consisted of many traditional schools; however, the district also offered choice programs at select schools designed for particular student interests. Many of the district's schools were moving towards choice programs to compete with the increasing number of charter schools arriving in the area. Presently, nine charter schools were competing with the district. The goal for the district, according to the superintendent, was for each school to foster its own personal identity, which is

believed to encourage student enrollment (Spencer, 2015).

The STEM innovation was a choice program many schools within the district were beginning to implement because it addressed many of the strategic priorities of the district which embraced (1) Globally Competitive Students, (2) 21st Century Professionals, (3) Healthy, Responsible Students, (4) Leadership Guides Innovation, and (5) 21st Century Systems (School District, 2018). Of those schools implementing the STEM innovation, three elementary schools (one in the northern end, one in the western end, and one in the southern end) were executing the STEM innovation. Table 1 depicts the mission and vision of the district, connecting the goal of the district and strategic priorities.

Table 1

District Mission and Vision

Mission	Vision
We are a premier school system where students come first. All students will receive a high quality, relevant education in a safe and caring environment which will produce confident, responsible and globally competitive citizens. Our students will be college and career ready.	Together, ensuring student success by igniting a passion for learning.

The mission of the district guided the ideas, and the method by which those goals were reached. The vision provided the purpose of the district. Together, the mission and the vision drive the work of each school in the district.

To maintain the respondent confidentiality of the three elementary schools implementing the STEM innovation, pseudonyms were used. The use of pseudonyms for qualitative research allowed for division among of the three schools, while organizing detailed information of the unique perspectives of each school (Kaiser, 2009). Sieber (1992) acknowledged that if data cannot be gathered anonymously, the researcher must

assemble, analyze, and describe data without conceding the identities of those involved in the research. The administration of each elementary school developed the pseudonym for use.

Setting of Heritage Elementary. Situated in the rural northern end of the county, the community of Heritage Elementary consisted of a large farming population. In 1846, the land initially held a 2-week religious revival gathering, in which "people came in covered wagons, pitched tents, [and] cooked over open fires" (Town of Heritage, North Carolina, n.d., para. 2). In 1906, the community of Heritage realized the district-created school was not meeting the learning needs of their children; therefore, in 1906 citizens of Heritage constructed the Heritage Academy, where students received elementary instruction as well as 2 years of high school (Heritage Elementary School, 2015). In 1908, Heritage Academy transitioned to Heritage Farm School and provided agriculture courses as well as traditional academic coursework (Town of Heritage, North Carolina, n.d.). At the time, only three other schools in the state offered this type of educational undertaking, making Heritage a unique place of learning (Heritage Elementary School, 2015). In 1916, the high school became a state accredited 4-year high school. In 1970, the high school was torn down, and a single story elementary school was erected in its place (Heritage Elementary School, 2015).

According to Onboard Informatics (2018), the Town of Heritage consisted of an area of only 1.38 square miles, and the population of the town consisted of 552 people. A gender breakdown revealed 42.5% (260) males and 52.8% (292) females. The demographics revealed 84.2% (447) of the residents were Caucasian, 9.8% (52) were Hispanic, 5.5% (29) were African American, and 0.6% (2) were other races. The

estimated income was $34,501. This salary is well below the average estimated $50,584 income of North Carolina residents (Onboard Informatics, 2018); however, it is important to note the population of Heritage Elementary included additional towns because of districting within the county.

Heritage STEM history. The history of realizing the STEM innovation at Heritage began during the 2015-2016 school year and a push for choice programs in schools (Heritage Elementary Administration, personal communication, July 17, 2018). Armed with new leadership, the administration looked to the history of the school and community to shape the school's choice program. Equipped with research, school leaders approached the entire staff and discussed the need for a choice program (Heritage Elementary Administration, personal communication, July 17, 2018). During these discussions, staff members revealed the need to stay relevant and improve school academics (Heritage Elementary Administration, personal communication, July 17, 2018). Together, staff members collaborated on different choice options from dual immersion to being a school dedicated to the arts; however, collectively members decided there be a need to stay true to the history of the community and members decided the STEM innovation allowed academics to merge with agriculture history (Heritage Elementary Administration, personal communication, July 17, 2018). With a choice program decided upon, leadership took the idea to the entire staff for a vote. With this vote, STEM education became the focus and required teachers to shift their mindset to one that incorporates the STEM innovation supporting the school mission and vision (Heritage Elementary Administration, personal communication, July 17, 2018).

Connecting STEM education and mission and vision. The history Heritage

expressed with the STEM innovation led members to develop the school's vision and mission statements. Table 2 represents the connection between the STEM innovation and the vision and mission of the school. The school's website provided information representing the mission and vision of the school.

Table 2

Heritage Elementary Mission and Vision

Mission	Vision
Heritage Elementary School will work as a team using STEM-Ag Education to meet and support the needs of all learners while developing curious and responsible students.	Heritage Elementary strives to exceed expected growth for all student by promoting Science, Technology, Engineering, Math and Agriculture (STEM-Ag) education through Problem Based Learning. In our classrooms, we create a nurturing environment where all students collaborate, problem solve, and innovate. We strive to produce problem-solving students who aspire to be successful in their community.

The mission and vision both revealed the goal of working towards the STEM innovation. Heritage Elementary incorporates agriculture into their STEM program, resulting in the name STEM-Ag. The history of the community and the school led educators to incorporate agriculture into the STEM innovation. Incorporating agriculture into the design of STEM relates learning to real-world problems involving the life of students and the community in a way that interests them and makes the learning relevant.

Heritage demographics. The North Carolina School Report Cards (2017) revealed Heritage Elementary served 421 students in grades prekindergarten through fifth grade during the 2016-2017 school year and was a Title I school. Table 3 depicts student demographics based on attendance for Heritage Elementary School (Heritage Elementary School, 2015).

Table 3

Student Demographics of Heritage Elementary

Subgroup	% of Students Represented Per Subgroup
Caucasian	67.6
Hispanic	22.1
African American	7.6
Multi-Racial	2.6
Exceptional Children	14
English as a Second Language	9
Free and Reduced Lunch	62

Table 3 revealed the demographics of Heritage Elementary were diverse; however, the majority of students were Caucasian, followed closely by Hispanics. More than half of the school's student population was identified as free and reduced lunch, meaning the households of these students had an income at or below 130% of the poverty income threshold (Snyder & Musu-Gillette, 2015). Table 4 depicts Heritage Elementary's educator demographics.

Table 4

Educator Demographics of Heritage Elementary School

Concentration	Number of Educators Per Concentration	Number of Educators with Advanced Degrees Per Concentration	Average Number Years of Experience Per Concentration
Prekindergarten	1	1	4
Kindergarten	4	1	16.25
First	4	0	13.5
Second	4	1	10
Third	3	1	25
Fourth	3	2	25
Fifth	3	2	23.3
Exceptional Children	1	0	12
English as a Second Language	1	1	3
Enhancements	4	0	20
Administration	1	1	14
Instructional Facilitator	1	1	14

Table 4 reveals the school had at least three teachers per kindergarten-fifth grade, with kindergarten, first, and second containing four teachers. Of the 30 educators, only 11 held an advanced degree; however, in every grade level, at least one teacher held an advanced degree. The exception to this finding is first grade. No teachers within this grade held an advanced degree. The school's population was below the district requirements of additional administration; therefore, the school only had one administration to lead educators and students.

Setting of Old Mountain School. Situated in the western part of the county, Old Mountain Elementary has been educating students since the time of the one teacher

school (Old Mountain Elementary Employee, personal communication, January 9, 2019). This first schoolhouse, built near the school's ground, existed during the Civil War. Heated by a large fireplace, the one-teacher school was constructed as an 8-foot-wide log cabin, in which water had to be carried from a nearby water source every day (Old Mountain Elementary Employee, personal communication, January 9, 2019). Sometime later, a new structure was erected; however, this structure also existed as a one-teacher school. In 1907, a first through seventh grade, two-room schoolhouse was constructed. Seven years later, an addition to the two-room schoolhouse was crafted and the school was renamed. Later, in 1926, Old Mountain Elementary was built in honor of the county's first female superintendent. To accommodate the students, curriculum was widened to include 11 grade levels, with a teacher for each of these grades (Old Mountain Elementary Employee, personal communication, January 9, 2019).

According to Onboard Informatics (2018), the town in which Old Mountain School was situated consisted of some area 20.5 square miles in size, and the population of the town contained 25,772 people. A gender breakdown revealed 47.1% (12,118) males and 52.9% (13,604) females. The demographics revealed 48.5% (12,740) of the residents were Caucasian, 35.3% (9,265) were African American, 11.5% (3,032) were Hispanic, 2.8% (733) were Asian, and 2% (523) were other races. The estimated income was $35,505. As previously mentioned, this salary was well below the average estimated $50,584 income of North Carolina residents (Onboard Informatics, 2018).

Old Mountain School STEM history. Old Mountain School became involved with the STEM innovation during the 2014-2015 school year due to district motivation. During this time the district encouraged schools to brand themselves (Old Mountain

Elementary Administration, personal communication, July 25, 2018). School leaders began exploring different options; however, leaders agreed the STEM innovation met the needs of the school (Old Mountain Elementary Administration, personal communication, July 25, 2018). According to the administration, the leaders wanted to pursue STEM education because the innovation promoted higher order thinking skills for students and best learning practices (Old Mountain Elementary Administration, personal communication, July 25, 2018). Through research, school leaders determined a significant demand for STEM jobs existed; therefore, these leaders wanted to prepare students to be college and career ready (Old Mountain Elementary Administration, personal communication, July 25, 2018). To achieve teacher buy-in, school leaders presented the benefits of becoming a STEM school involving student participation. To accomplish this involvement, school leaders invited a science organization specializing in active learning to provide workshop sessions focusing on inquiry that allowed students to experience comprehensive understanding of STEM ideologies (Old Mountain Elementary Administration, personal communication, July 25, 2018). Through this experience, teachers were able to experience the benefits of becoming a STEM school and committed to the practice of implementing the innovation.

Connecting STEM education and mission and vision. The STEM innovation influenced Old Mountain School's team to develop a vision and mission statement; therefore, the innovation became part of the working goals of the school. Table 5 represents the connection between the STEM innovation and the vision and mission of the school. The school's website provided information representing the mission and vision of the school.

Table 5

Old Mountain Elementary School Mission and Vision

Mission	Vision
Old Mountain School's mission is to challenge and educate all students, creating leaders ready to explore and thrive through the use of the STEM innovation, generating excellence in all members of the school community.	Challenging and Educating Future Leaders

The mission and vision of the school revealed the goal of preparing students to be college and career ready focusing on educating future leaders. In pursuing STEM education, educators wanted to challenge all students to learn through exploration and inquiry, thus the STEM innovation was highlighted in the revised mission and vision.

Old Mountain School demographics. The North Carolina School Report Cards (2017) revealed Old Mountain School served 523 students in grades prekindergarten through fifth grade during the 2016-2017 school year and was a Title I school. Table 6 depicts student demographics based on attendance for Old Mountain School (Old Mountain Elementary Administration, personal communication, July 25, 2018).

Table 6

Student Demographics of Old Mountain Elementary School

Subgroup	% of Students Represented Per Subgroup
Caucasian	78
African American	12.5
Hispanic	6.11
Asian	2.97
Other	.33
Exceptional Children	8.6
English as a Second Language	4.2
Free and Reduced Lunch	72

Table 6 reveals the demographics of Old Mountain School are slightly diverse; however, the majority of students are Caucasian. The school expresses a high population of students identified as free and reduced lunch. Almost three fourths of the student population are identified as free and reduced lunch. This expressed number qualified the school as a Title I school. Table 7 depicts Old Mountain School's educator demographics.

Table 7

Educator Demographics of Old Mountain School

Concentration	Number of Educators Per Concentration	Number of Educators with Advanced Degrees Per Concentration
Prekindergarten	2	0
Kindergarten	4	1
First	5	2
Second	4	1
Third	4	1
Fourth	4	1
Fifth	4	3
Exceptional Children	2	1
English as a Second Language	1	0
Enhancements	6	2
Administration	2	2
Instructional Facilitator	1	1

Table 7 reveals the school had at least four teachers per kindergarten-fifth grade and two prekindergarten teachers. First grade expressed a higher number of students; therefore, this grade level had an additional teacher. Of the 39 educators, only 15 held an advanced degree; however, the administration spoke to at least one additional educator

working towards their master's degree (Old Mountain Elementary Administration, personal communication, July 25, 2018). The school's population expressed a high number of students per the district requirements of receiving additional administration; therefore, the school only had one principal and one vice principal. The school also employed an instructional facilitator who facilitated each professional learning community. The school was unable to supply the researcher with the average number of years of experience per concentration; therefore, the researcher was unable to include data in Table 7.

Setting of Louis Armstrong Elementary. A newer school in the district, Louis Armstrong Elementary opened doors during the 1998-1999 school year. Located in the southern end of the district, the area experienced a vast population influx due to the popularity of the region; therefore, the school began as a way to "relieve the pressure of students and families moving into the area" (Louis Armstrong Elementary Administration, personal communication, July 9, 2018). The elementary school is unique in that it shares a combined building with the middle school, creating a one-campus environment. "The elementary school houses an EC PreK room, k-5 classrooms, and a district EC classroom" (Louis Armstrong Elementary Administration, personal communication, July 9, 2018). In the past, the school also housed two district EC classrooms.

According to Onboard Informatics (2018), the town in which Louis Armstrong Elementary is situated consists of some area 14.7 square miles in size, and the population of the town contained of 35,300 people. A gender breakdown revealed 50% (17,634) males and 50% (17,666) females. The demographics revealed 74.7% (26,964) of the

residents were Caucasian, 9.8% (3,532) were African American, 9.3% (3,352) were Hispanic, 3.9% (1,419) are Asian, and 2.29% (829) are other races. The estimated income was $65,937. Compared to the other two schools, the town in which Louis Armstrong Elementary was located was above the average estimated $50,584 income of North Carolina residents (Onboard Informatics, 2018).

Louis Armstrong STEM history. The history of realizing the STEM innovation at Louis Armstrong began with a single teacher who became interested in the idea of implementing the innovation. At the same time, with an increase in "pressure of school options, choice and charter schools, each elementary school was tasked with defining themselves to be marketable and competitive with other schools in the area" (Louis Armstrong Elementary Administration, personal communication, July 9, 2018). Together, the teacher and principal worked to move towards exploring and implementing the innovation; however, the idea of implementing the innovation began with the understanding to start small. "By the end of the year, the staff voted if they were interested in continuing the STEM track, 100 percent of teachers voted yes" (Louis Armstrong Elementary Administration, personal communication, July 7, 2018). To begin the STEM journey, school educators visited a neighboring school district implementing the innovation and began working with Wake Forest University and Dr. Stan Hill to implement the problem-based learning portion of the STEM innovation (Louis Armstrong Elementary Administration, personal communication, July 7, 2018). Additionally, the school's administration stated educators of the school regularly conversed about the innovation and worked towards initiating change in their instructional practices due in part to creating an environment that is suitable for the

learning students need today (Louis Armstrong Elementary Administration, personal communication, July 9, 2018).

Connecting STEM education and mission and vision. The STEM innovation has become an integral part of Louis Armstrong Elementary; therefore, the mission and vision statement developed by the school's educators depict a shared value between their goals and the goals of the STEM innovation. Table 8 represents the connection between the STEM innovation goals and the vision and mission of the school. The school's website provided information representing the mission and vision of the school.

Table 8

Louis Armstrong Elementary Mission and Vision

Mission	Vision
Louis Armstrong Elementary School will work together to achieve high academic growth for all of our students. We will accomplish this through the collaboration, communication and trust between home, school, and the community.	A school dedicated to fostering lifelong learners and responsible citizens.

Included in the mission and vision statement is the plan of sharing responsibility between the school and private resources. North Carolina's STEM Education Strategic Plan (Public Schools of North Carolina, n.d.b), priority two goal describes gaining and sustaining community support for the innovation. To achieve this goal, the school regularly conversed with stakeholders to uphold the values of the school as well as the innovation.

Louis Armstrong demographics. The North Carolina School Report Cards (2017) revealed Louis Armstrong Elementary served 652 students in grades prekindergarten through fifth grade during the 2016-2017 school year and was not a Title I school. Table 9 depicts student demographics based on attendance for Louis Armstrong

Elementary School (Louis Armstrong Elementary Administration, personal communication, July 7, 2018).

Table 9

Student Demographics of Louis Armstrong Elementary

Subgroup	% of Students Represented Per Subgroup
Caucasian	80
African American	5
Hispanic	9
Asian	4
Multi-Racial	3
Exceptional Children	12
English as a Second Language	15
Free and Reduced Lunch	24

Table 9 revealed the demographics of Louis Armstrong Elementary were unlike the demographics of the two other sites involved in the research. The majority of students were Caucasian and less than a fourth of the school's population were identified as being below 130% of the poverty income threshold. Table 10 depicts Louis Armstrong's educator demographics.

Table 10

Educator Demographics of Louis Armstrong Elementary School

Concentration	Number of Educators Per Concentration	Number of Educators with Advanced Degrees Per Concentration	Average Number Years of Experience Per Concentration
Prekindergarten	1	1	8
Kindergarten	5	2	17.2
First	5	2	15
Second	5	2	15
Third	5	2	11.8
Fourth	5	2	14.8
Fifth	5	0	17.8
Exceptional Children	3	2	15.3
English as a Second Language	1	0	NA
Enhancements	6	5	17.2
Administration	2	2	16
Instructional Facilitator	1	1	20

Table 10 reveals the school had an average of five teachers per grade level. Additionally, while most grade levels had educators with advanced degrees, fifth-grade expressed no degree of advancement. Also, because of the population of the school, the school had two administrators to lead the school. The table also revealed a total of 44 educators are employed at the school, with 21 of them holding an advanced degree.

Research Design and Rationale

The research investigation observed a sequential explanatory mixed methods design combining the postpositivist paradigm and Kurt Lewin's model of organizational change. These theories allowed the researcher to assume the role of learner and

incorporate the three-step process reflecting upon an organization's change in the implementation process. As explained by Creswell (2014), this mixed methods design allowed the researcher to lead with quantitative research and then build upon the results by conducting detailed qualitative research. The aim for conducting an explanatory sequential mixed methods investigation was in using both quantitative and qualitative exploration to understand the extent to which elementary educators are prepared in implementing the STEM innovation. To achieve this goal, the researcher investigated elementary educators' perspectives of implementing the STEM innovation in three elementary schools as well as characterized successes and challenges associated with implementing the STEM innovation. This design allowed "multiple forms of data drawing on all possibilities" (Creswell, 2014, p. 17).

The quantitative segment of the investigation was accomplished through the combining of the theoretical and conceptional frameworks, which stressed meaning and strived to bring together theory and practice as well as understanding the needs of educators in shifting and changing instructional practices towards the STEM innovation (Hussain et al., 2016; Ryan, 2006). The quantitative findings, according to Gliner, Morgan, and Leech (2009), were presented objectively, allowing for quantifiable findings through data examination. To achieve quantitative findings, the researcher created a survey that was to be administered to the educators of the three elementary schools involved in the study. The goal of the survey was to gain elementary educator understandings, perceptions, successes, and challenges of implementing the STEM innovation. One survey was given to all teachers to gain their perspectives. Additionally, a leadership survey was given to school leaders to gain their perspectives.

When analyzed together, the teacher survey and leadership survey provided quantitative data depicting educator perspectives.

To explain the quantitative data results further, qualitative data were explored. Kitzinger (1995) explained surveys are suitable for attaining quantitative explanations of a person's predefined opinion, but focus groups provide a sound way of exploring how those predefined opinions are composed. Additionally, Creswell (2014) supported the use of this type of qualitative research, stating they are "intended to elicit views and opinions from the participants" (p. 190) by providing research informing the study through collaboration with participants involved; therefore, focus groups were utilized to fill and explain any gaps in the quantitative data (Kitzinger, 1995).

Role of the Researcher

This sequential explanatory mixed methods design entailed two distinct phases. In the first phase, quantitative research was collected and analyzed using a researcher-created survey. The second phase involved qualitative research explaining and elaborating on the quantitative results found in the initial phase by utilizing focus groups. As a result of these two phases, the researcher had two roles.

Simon (2011b) explained that in a mixed method study, the researcher's role will be different depending on the quantitative portion or qualitative portion of the study. In the quantitative piece, "the researcher's role is, theoretically non-existent" (Simon, 2011b, p. 1), meaning participants were detached from the researcher; however, Simon (2011b) mentioned that in quantitative studies, research should ideally be "repeatable by others and, under the same conditions, should yield similar results … without regard to the participants or the person collecting the data" (p. 1). With these conditions in mind,

the researcher, along with the collaboration of others, created the understanding and perceptions educator surveys (teacher and leadership) to produce similar results when repeated by others. This quantitative piece allowed the researcher an unbiased theoretically nonexistent role in which she was an observer.

The qualitative phase, however, required the researcher to explain the statistical data found in the quantitative phase by exploring the views of focus group participants more complexly (Creswell, 2014; Simon, 2011b); therefore, the researcher's role was different. In this phase, the researcher became the *human instrument* and collected data, which can lead to bias (Simon, 2011b). Morgan (1997) noted focus groups are conducted using a selected number of participants from a constrained number of sources.

> Such "bias" is a problem only if ignored—that is, interpreting data from a limited sample as representing a full spectrum of experiences and opinions. If a particular recruitment source does limit the nature of the data that are available, then this forces the choice between living with those limitations or finding other sources of participants that will reduce these biases. (Morgan, 1997, p. 6)

Therefore, to maintain the researcher minimized bias, focus group sessions were observed, recorded, transcribed, and reviewed by an unbiased individual. Once sessions were transcribed and reviewed, organization and preparation of data for analysis occurred (Creswell, 2014). The researcher read through all qualitative data responses and coded each response categorizing each response into themes to address specific results found in the statistical data (Creswell, 2014).

Population and Sampling Procedure

Population. Blair, Czaja, and Blair (2014) defined the population as those in

which the researcher would like to make deductions. In this research, the goal was to investigate the extent to which elementary educators are prepared in implementing the STEM innovation; therefore, research was conducted using elementary educators' perspectives. However, elementary educators present a large population size. As a result, the researcher was unable to gain perspectives from every elementary educator implementing the STEM innovation; thus, Creswell (2014) suggested identifying the *purposefully selected* sites for the proposed research. Therefore, the researcher purposed researching in the district in which they were employed for convenience. The district included 17 elementary schools, and three of those were implementing the STEM innovation; therefore, these three elementary schools were purposefully selected to participate in the research. Additionally, the sampling design for the population was to be multistaged (clustered). Creswell (2014) noted in multistage sampling, "the researcher first identifies clusters (groups or organizations), obtains names of individuals within those clusters, and then samples within them" (p. 158). Three elementary schools were identified in the study. As a result, the researcher obtained the name of those within each institution from the school's leadership and then sampled within them.

Each school involved in the research began implementing the STEM innovation at different times based on needs of the school. Heritage Elementary employed 28 teachers and two school leaders and began implementing STEM innovation during the 2016-2017 school year; however, one teacher was a new hire and did not participate in the survey. Therefore, 27 teachers represented the population of teachers at Heritage Elementary. Old Mountain School employed 36 teachers and three school leaders and began implementing the STEM innovation during the 2015-2016 school year; however,

three teachers were considered new hires and did not participate in the survey. Therefore, 33 teachers represented the population of teachers at Old Mountain School. Additionally, Louis Armstrong Elementary employed 41 teachers and three members of leadership and began implementing the STEM innovation during the 2014-2015 school year; however, four teachers represented new hires. Therefore, 37 teachers represented the population of teachers at Louis Armstrong Elementary. Even though each school began implementing the STEM innovation during different school years, each school provided educator perspectives involving implementation of the STEM innovation.

Sampling. To obtain statistically significant quantitative results of the survey, Creswell (2014) suggested a random sampling from each of the school's populations. Keppel and Wickens (2003) supported this suggestion, stating random sampling from the selected population ensures data collected would represent the population. Krejcie and Morgan (1970) acknowledged a method to determine the sample size of the representative population needed to be given; therefore, using the National Education Association published formula for determining the sample size of the population, found in the Krejcie and Morgan text, a sample size of those needed to complete the survey was constructed from each school's population. A total of 105 teachers were employed at the three schools; however, of these 105 teachers, eight were new to the school and did not take part in the teacher survey. Figure 3 displays the National Education Association formula for determining the sample size of the population found in Krejcie and Morgan.

$$s = X^2NP(1 - P) \div d^2(N - 1) + X^2P(1 - P).$$

s = required sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P = the population proportion (assumed to be .50 since this would provide the maximum sample size).

d = the degree of accuracy expressed as a proportion (.05).

Figure 3. Formula for Determining Sample Size. This formula was used to determine the sample size needed for each schools' population in responding to the survey items to determine understandings, perceptions, successes, and challenges of implementing the STEM innovation.

When using the above formula, a determination was made identifying the sample size needed of survey respondents. Table 11 shows the number of respondents needed to suffice the identified sample size based on the population of each school.

Table 11

Survey Respondent Sample Size Based on Combined Population

Population Descriptor	Population	Population Sample Size
Teacher	97	78
Leadership	8	8

Using the formula provided by the National Education Association (Krejcie & Morgan, 1970), David Blevins (personal communication, July 30, 2018) stated 78 teacher respondents are needed and eight leadership respondents are needed to respond to each survey to determine understandings, perceptions, successes, and challenges of implementing the STEM innovation.

Kitzinger (1995) explained that while surveys are suitable for acquiring quantitative data, focus groups should be to explored to study the opinions of

respondents; therefore, in the qualitative phase of research, focus groups were used to explain the quantified survey results further. Morgan (1997) determined a number of rules regarding focus groups: (1) use homogeneous strangers, (2) rely on a structured format, (3) have between six to 10 participants per group, and (4) have between three to five groups per research topic. According to Creswell (2014), focus group interviews should consist of "six to eight interviewees in each group" (p. 190); however, Morgan (1997) also stated for rule number one that involving friends as well as colleagues can encourage focus group participants to relate to the comments being shared. Therefore, the participants of each focus group session were homogeneous strangers. Instead, participants were homogeneous colleagues experiencing the same implementation of the innovation in the same school. Additionally, Morgan (1997) noted including hierarchy in a focus group session may result in participants not sharing truthfully, thus affecting the qualitative data given; therefore, each school's educators were separated into either a teacher focus group or a leadership focus group.

Variables

Creswell (2014) documented that variables are characteristics of an organization that can be evaluated and vary among those being studied. Furthermore, variables need to be identified in the research for one to understand "what groups are receiving treatment and what outcomes are being measured" (Creswell, 2014, p. 169). Through this sequential explanatory mixed methods research, the study examined two dependent variables: understandings as well as perceptions of elementary educators. These dependent variables are the outcomes of the independent variable, which is the implementation of the STEM innovation.

Instrumentation

When conducting a study, the researcher attained data and built observations using instruments (Creswell, 2014). Two forms of instrumentation were applied in this mixed methods study: educator surveys (teacher and leadership) and focus groups. Appendix A (Instrumentation and Method of Analysis Matrix) illustrates the instruments and methods of analysis as they connect to the five hybrid research questions directing the study.

Data Collection Procedures

Creswell (2014) mentioned mixed method studies use multiple forms of data to draw results. In this explanatory sequential mixed methods study, two sources of instrumentation were used to gather data. In the first phase, a survey was administered to both teachers and school leadership to gain understandings, perceptions, successes, and challenges of implementing the STEM innovation. In the second phase, three teacher focus groups were conducted at each elementary school to explain survey results further. Additionally, one leadership focus group session was conducted at a district agreed upon location. Only eight individuals identified as school leaders had the option to participate in the focus group; therefore, the small number allows for this focus group to combine into one leadership focus group. This decision was supported by Creswell (2014) who stated there should be between six to eight participants in each interview group. The following information describes the first and second phase collection procedures.

Phase 1: Educator surveys. According to Blair et al. (2014), surveys gather research data through questioning a specific population; therefore, internet surveys conducted through SurveyMonkey were sent to the educators at each of the three

elementary schools. An external link was provided to the school's administration who sent the survey link to either those identified as a teacher or a school leader. The survey was designed to be given to only those employees identified as a teacher or those in the leadership department. Respondents had 3 weeks to complete the surveys. Follow-up reminders were sent to the school's administration who forwarded the email to the school's educators. Once the 3 weeks were complete and the survey ended, each item was analyzed independently and coded. Likert scale items were presented using percentage frequency distribution. Open-ended responses were analyzed independently and responses were coded. Codes were clustered to identify themes and patterns in responses (Provalis Research, n.d., para. 5). Dichotomous and multiple response items were analyzed independently using percentage frequency. Additionally, numerical response questions were analyzed independently and responses were categorized using percentage frequency.

Teacher survey. To participate in the teacher survey (Appendix B), the respondent needed to meet specific criteria. All classroom teachers, grades prekindergarten to fifth, were selected. Additionally, enhancement teachers as well as exceptional children teachers and English as a Second Language (ESL) teachers were also given the teacher survey, as they have participated in professional learning experiences involving implementing STEM innovation and were encouraged to work with classroom teachers in implementing the innovation. First-year teachers were not given the survey to complete since these individuals were new to the innovation. Additionally, teachers who were new to the school did not participate in the survey. To ensure these individuals' responses were not included in the data, these individuals were

locked out of the survey depending on their demographic response.

The teacher survey had 53 questions and was divided into six classified sections. Blair et al. (2014) noted a respondent's decision to participate in the survey occurs in stages. The first stage was the survey's introduction. In the introduction, the participants were introduced to the subject and purpose of the survey. "It gives the prospective respondent sufficient information about the study to satisfy the needs of informed consent" (Blair et al., 2014, p. 214). This initial stage allowed the participant to grasp information about the survey and whether to proceed.

Teacher survey section one. The first six items (1-6) addressed background information (demographics) about the respondent. Each section of the survey thereafter focused on addressing a research question. Once respondents were guided through the demographic items, they were either directed to the teacher survey or leadership survey, depending on their current employed position. As mentioned previously, first-year teachers and teachers new to the school were locked out of the survey. According to Blair et al. (2014), after preliminary demographic items, initial survey questions also determine if participants will continue responding to a survey; therefore, the initial questions were chosen based on suggestions from Blair et al. (2014). They suggested the initial questions (1) be easy to read, (2) be interesting, (3) apply to and be answerable by most respondents, and (4) be closed format; therefore, the open-ended response questions needed for Research Question 1 were moved to section three of the survey.

Teacher survey section two. Section two addressed Research Question 2, "To what extent are STEM instructional practices being implemented?" These 16 questions (7-22) examined the STEM instructional practices being implemented at the school

and/or in the respondent's classroom. Likert scale questions were used for 12 of the items. These 12 questions asked respondents to select the response best describing their belief of STEM instructional practices implemented in their school and/or classroom. The additional four questions were dichotomous response items in which respondents were asked if they were introduced to a specific feature of the STEM innovation.

Teacher survey section three. Section three contained five open-ended questions (23 and 25-28) and one multiple response listed item (24). This section addressed Research Question 1, "How can elementary educators' perceptions and understandings of the STEM innovation be described?" This section used different formats to allow teachers to express their understanding of the STEM innovation and how it relates to education. The five open-ended questions asked respondents to provide descriptions of their current understandings of the STEM innovation. The opened-ended responses were needed to gain an understanding of educator perceptions and understandings of the STEM innovation. Question 24, the multiple response listed item, was designed to gain an understanding of the top three important reasons to implement the STEM innovation in the elementary classroom. Panel members felt respondent choice for this question was best in gaining the top three most important reasons to implement the innovation.

Teacher survey section four. Section four addressed Research Question 3, "How do elementary educators characterize successes and challenges in implementing the STEM innovation?" This section is divided into two subsections, with the first subsection focusing on four questions (29-32) involving characterizing successes of implementing the STEM innovation. In this section, three multiple response listed items were used to gain an understanding of teacher perceptions of successes involving the

STEM innovation. One open-ended question (32) found in this section asked respondents to describe their personal successes in implementing the STEM innovation. The second subsection involved four questions (33-36) characterizing challenges in implementing the STEM innovation. The subsection of challenges involved three different types of questioning. Two dichotomous response items (33-34) required respondents to choose one thing their leadership team could have offered or they could have accomplished to make implementation successful. The multiple response item (35) allowed respondents to choose the top three important challenges faced when implementing the STEM innovation. Question 36, the open-ended response item, asked teachers to describe what challenges and struggles they experienced while implementing the STEM innovation. Panel members wanted to have this question open ended because they believed it allowed teachers to express in detail their struggles during the implementation process.

Teacher survey section five. Section five was divided into four subsections. The literature review focused on four supports of the STEM innovation: funding, changing mindsets, supports for STEM (addressed as resources in the survey), and professional learning (addressed as professional development in the survey); therefore, the survey mimics these four support structures. Each subsection was divided in a way to answer Research Question 4, “To what extent are elementary educators supported in their implementation of the STEM innovation?” In the teacher survey, the first subsection involved funding of the innovation. The first question (37) involved a dichotomous response question asking respondents if their school received funds for implementing the innovation. Depending on this question’s response, respondents were directed towards

an open-ended response item (38) or directed to the next subsection of growth mindset. The open-ended response item asked respondents to describe how school-received funds were used. The second subsection focused on supporting the growth mindset of the teacher. Question 39 asked respondents a dichotomous response question of did they feel supported by school leaders during the implementation process. Depending on their response to this question, respondents were directed to an open-ended question (40) asking them to describe how they were supported by school leaders or logic to question 41. Question 41 also involved a dichotomous response question asking respondents if they felt supported by other teachers through the implementation process. If respondents answered yes to this dichotomous item, they were directed to question 42 in which they were asked how other teachers supported them through the implementation process. If respondents answered no they were not supported, they were directed to the next subsection. Subsection three focused on the resources needed in implementing the STEM innovation. In this subsection, three questions were asked. One question (item 43) used a dichotomous response item to allow respondents to choose one response categorizing their belief of if they have sufficient access to STEM resources. The two following questions (44 and 45) used multiple response items to ask respondents where they obtained the materials needed and what resources the school provided to make the STEM innovation successful in the classroom. The fourth subsection involved professional development needed in implementing the STEM innovation. Two questions were asked of respondents in this subsection. The first question (item 46) was asked in dichotomous response format. Respondents were asked to choose one response from the list. The question asked respondents how many school-offered STEM professional

development sessions they attended. The next question (item 47) involved a multiple response item asking respondents to choose all responses that apply to the question what STEM professional development opportunities they have received.

Teacher survey section six. Section six addressed Research Question 5, "How could the STEM innovation be further supported in the elementary classroom?" This section was also divided into four subsections; those being funding, changing mindsets, resources, and professional development. The first subsection involved funding. The first question in this subsection (item 48) asked respondents to choose one thing they could work towards to increase funding for the STEM innovation in their classroom. The second subsection involved further supporting the growth mindset. Questions 49 and 50 provided respondents with dichotomous response items asking them to describe one thing their school leaders could do and they could do to further improve their STEM mindset. The third subsection involved resources needed to further support the implementation of the STEM innovation. This one multiple response question (item 51) asked respondents what additional resources they need for further successful implementation of the innovation. The fourth subsection focused on professional development needed in further supporting the elementary classroom in implementing the STEM innovation. This one question (item 52) asked respondents a multiple response question addressing what further professional development experiences are needed to help them implement the STEM innovation successfully. The last question (item 53) asked respondents if they were interested in taking part in a teacher focus group session. Depending on their response, the respondent was transferred to a page requesting contact information and then they submitted their results; if respondents were not interested in taking part in the

focus group session, they were asked to submit their results without entering contact information.

Leadership survey. To participate in the leadership survey (Appendix C), the respondent needed to meet specific criteria. All those considered leadership (principal, vice principal, and instructional facilitator) were provided access to the leadership survey depending on their response to the demographic item asking respondents their current position of employment.

The leadership survey had 52 questions and was divided into six classified sections. Each section of the survey focused on addressing a research question, except section one in which respondents were asked to submit their demographic information.

Leadership survey section one. The first six items (1-6) addressed background information (demographics) about the respondent. Each section of the survey thereafter focused on addressing a research question. Once respondents were guided through demographic items, they were either directed to the teacher survey or leadership survey depending on their current employed position.

Leadership survey section two. Section two addressed Research Question 2, "To what extent are STEM instructional practices being implemented?" These 15 questions (7-21) examined the STEM instructional practices being implemented at the school. Likert scale questioning was used for 11 of the items. These 11 questions asked respondents to select the response best describing their belief of STEM instructional practices implemented at their school. The additional four questions (11-12 and 15-16) were dichotomous response items in which respondents were asked if they were introduced and if their staff members were introduced to a specific feature of the STEM

innovation.

Leadership survey section three. Section three contained five open-ended questions (22 and 24-27) and one multiple response listed item (23). This section addressed Research Question 1, "How can elementary educators' perceptions and understandings of the STEM innovation be described," and used different formats to allow school leaders to express their understanding of the STEM innovation and how it relates to education. The five open-ended questions asked respondents to provide descriptions of their current understandings of the STEM innovation. The opened-ended responses were needed to gain an understanding of educator perceptions and understandings of the STEM innovation. Question 23, the multiple response listed item, was designed to gain an understanding of the top three important reasons to implement the STEM innovation in the elementary classroom.

Leadership survey section four. Section four addressed Research Question 3, "How do elementary educators characterize successes and challenges in implementing the STEM innovation?" This section was divided into two subsections, with the first subsection focusing on four questions (28-31) involving characterizing successes of implementing the STEM innovation. In this section, three multiple response listed items (28-30) and one open-ended item (31) were used to gain an understanding of school leaders' perceptions of successes involving the STEM innovation. The open-ended item allowed respondents to describe their leadership team successes in helping teachers implement the innovation. The second subsection involved three questions (32-34) characterizing challenges in implementing the STEM innovation. The subsection of challenges involved three different types of questioning. Question 32, the dichotomous

response item, required respondents to choose one thing their leadership team could have offered or they could have accomplished to make implementation successful. Panel members wanted respondents to choose one response to narrow down a specific offering. The multiple response item (33) allowed respondents to choose the top three important challenges faced when implementing the STEM innovation. Question 34, the open-ended response item, asked school leadership to describe what challenges and struggles they experienced while implementing the STEM innovation.

Leadership survey section five. As with the teacher survey section five, section five of the leadership survey was also divided into four subsections based on items identified in the literature review. Each subsection was divided in a way to answer Research Question 4. "To what extent are elementary educators supported in their implementation of the STEM innovation?" In the leadership survey, the first subsection involved funding of the innovation. The first question (35) involved a dichotomous response question asking respondents if their school received funds for implementing the innovation. Depending on this question's response, respondents were directed towards two open-ended response items (36 and 37) or directed to the next subsection of growth mindset. Question 36 asked respondents to describe how school-received funds were used and question 37 asked school leaders from where those funds were received. The second subsection focused on supporting the growth mindset of those involved with the STEM innovation. Question 38 asked respondents a dichotomous logic response question addressing if they felt supported by district leaders during the implementation process. Depending on their response to this dichotomous logic question, respondents were directed to an open-ended question (item 39) asking them to describe how they were

supported by district leaders. Question 40 asked respondents how school leaders supported teachers' growth mindset through the implementation process. The next subsection involved resources needed in implementing the STEM innovation. In this subsection, two questions were asked. One question (item 41) used a dichotomous response item to allow respondents to choose one response categorizing their opinion addressing if they believe teachers have sufficient access to STEM resources. The following question (item 42) used multiple response questions to ask respondents what resources the school provided to make the STEM innovation successful in teachers' classrooms. The fourth subsection involved professional development needed in implementing the STEM innovation. Four questions were asked of respondents in this subsection. The first three questions (43-45) required respondents to provide numerical information concerning how many professional development sessions their school provided during the previous school year and how many STEM professional development sessions were offered. These responses were used to gain a percentage of how the innovation was supported. The next question (item 46) involved a multiple response item asking respondents to choose all responses that apply to the question of what STEM professional development opportunities they have received.

Leadership survey section six. Section six addressed Research Question 5, "How could the STEM innovation be further supported in the elementary classroom?" Additionally, this section was also divided into four subsections; those being funding, changing mindsets, resources, and professional development. The first subsection involved funding. This question (item 47) asked respondents a dichotomous item requesting them to choose one thing they could work towards to increase funding for

STEM. The second subsection involved further supporting the growth mindset. Questions 48 and 49 provided respondents with a dichotomous response item asking them to describe one thing their school leaders could do and they could do to support further STEM mindset growth. The third subsection involved resources needed to further support the implementation of the STEM innovation. This one question (item 50) asked respondents what additional resources their teachers need for further successful implementation of the innovation. The fourth subsection focused on professional development needed in further supporting the elementary classroom in implementing the STEM innovation. This one question (item 51) asked respondents a multiple response item allowing them to choose what further professional development experiences would help teachers successfully implement the STEM innovation. The last question (item 52) asked respondents if they were interested in taking part in a leadership focus group session. Depending on their response, the respondent was transferred to a page requesting contact information. Once information was provided, respondents could submit their results; or if respondents were not interested in taking part in a focus group, they were asked to submit their results without entering contact information.

Phase 2: Focus groups. Kitzinger (1995) acknowledged surveys are appropriate for describing certain opinions, but focus groups offer explanations of how those opinions were formed. Furthermore, research suggested focus groups allow participants to become an active part of the research, permitting them to engage in conversations that are relatable to what was being discussed (Kitzinger, 1995). Additionally, they offer a process that can help participants explore and refine their opinions (Kitzinger, 1995). In phase two of the study, focus groups sessions were conducted at each of the three

elementary schools. Kitzinger (1995) and Morgan (1997) described focus groups as a form of group interview that profits from the interactions of participants. These interactions encouraged participants to explore the issues being discussed as well as empowered them to be a voice of the innovation.

After surveys were complete, six to 10 teacher respondents from each school and leadership respondents received an additional follow-up email from the researcher. A follow-up email confirmed participation in the focus group session. Once focus groups were formed, teacher focus group sessions began at each of the three elementary schools. Additionally, one leadership focus group session occurred at a location of the district's choosing. A total of four focus group sessions were used: three teacher and one leadership. Once all participants of the focus group session were determined, an email was sent to administration to set up a time to conduct the sessions at the school's location. The focus group sessions took place at each of the involved schools in the study for teacher convenience. To protect identities, the email to administration only discussed times and location of each session and did not involve names. To also protect identities, each focus group session was led by the researcher, and only teachers were involved in the teacher sessions and only leadership in the leadership sessions; however, an outside observer/notetaker was a member of the sessions as well to provide additional detached open-ended narrative observations. This member was an educator familiar with the STEM innovation but was not affiliated with the school. During the focus group sessions, conversations were recorded to aid in gathering precise qualitative data. After each focus group was completed, transcripts of the sessions were examined and analyzed for common themes. The themes were used to provide additional support for the

quantitative data. Additionally, detached open-ended narrative observations were conducted by the notetaker and researcher during each session; therefore, observational protocols for recording the observed information were developed (Creswell, 2014).

Glickman et al. (2018) noted qualitative observations “are alternative means of observing” and are conducted “with a general focus or no focus at all and record events as they occur” (p. 203). In the focus group sessions, specific questions were asked based on questions from a survey given to the staff prior to the sessions. Even though recordings of the focus group sessions were transcribed, detached open-ended narrative notes were transcribed by the researcher and the observer/notetaker during the sessions. Additionally, Creswell (2014) supported this view and recommended researchers take notes, even if the interview is recorded, “in the event that recording equipment fails” (p. 194). Utilizing these notes allowed the researcher to recall the people involved and the things that attracted attention while those being interviewed answered questions (Glickman et al., 2018).

Teacher focus groups. Teacher focus groups followed a specific “interview protocol for asking questions and recording answers” (Creswell, 2014, p. 194). The introduction introduced participants to the objective of the focus group as well as stated sessions were to be recorded and allowed participants to withdraw from the session at any time without penalty. The introduction also allowed participants to ask any questions should they have arisen before the questions began. Once participants were clear about the course of the focus group discussion, nine questions were asked. The first question, as suggested by Creswell (2014), consisted of an ice-breaker question. This question addressed STEM education as having different meanings to different people and allowed

participants to describe their understanding of STEM education. As mentioned in the literature review, research showed the STEM innovation has been described many ways; and North Carolina's definition of the term encompasses an expansive perspective as well and can lead to many interpretations. This ice-breaker question allowed each participant to share their interpretation. A probe question (question 2) was used to follow up and ask individuals why they thought elementary schools should implement the innovation. In addition, this ice-breaker question and probe question also corresponded to Research Question 1. The third and fourth focus session questions addressed Research Question 2 involving instructional practices. Question three spoke to the understanding STEM requires educators to change their traditional instructional practices to practices that support the STEM innovation. The question provided an opportunity for participants to describe how they prepared to change their traditional practices to practices that support STEM. Question four probed participants into talking about how they are implementing the STEM innovation in their classroom. The next two questions (5 and 6) addressed Research Question 3 and provided participants a chance to describe their successes and challenges in implementing the innovation. Following these questions, the seventh question focused on Research Question 4 and asked participants to think about the current support they receive. This question provided participants with a chance to describe supports they received that encouraged them to transition to instructional practices that support STEM education. The final focus group question (question 8) spoke to Research Question 5. This final question emphasized future support and asked participants to explain how STEM could be further support in the elementary classroom.

Leadership focus groups. Regarding the leadership focus group questions, the

protocol was the same as the teacher focus group sessions. The only change involved the wording in some of the questions. As with the teacher focus group sessions, leadership sessions first introduced participants to the objective of the session and stated sessions were to be recorded as well as informed participants they could withdraw from the session at any time without penalty. Once participants understood the introduction to the session, eight questions were asked. The first question consisted of an ice-breaker question and asked them to describe their understanding of STEM education. A follow-up question (question 2) addressed that many secondary schools are implementing the innovation but asked why do they think elementary schools should implement the innovation as well. Both question one and question two directed responses to answer Research Question 1. Focus group questions three and four tackled Research Question 2. These two questions involved instructional practices and asked participants to describe how their leadership team prepared teachers to change traditional instructional practices to practices that support STEM education. The next two questions (5 and 6) provided an opportunity for participants to describe what their leadership team accomplished to encourage teachers to implement STEM successfully and what they noticed were some challenges when encouraging teachers to implement STEM. Following these questions, the seventh question focused on Research Question 4 and asked participants to think about the current support the school receives. This question provided participants with a chance to describe these supports. The final focus group question (question 8) spoke to Research Question 5. This final question highlighted future support and asked participants to explain how STEM could further support their school.

Validity and Reliability

Blair et al. (2014) mentioned, "Validity requires, first, that the questions measure the dimension or construct of interest and, second, that respondents interpret the question as intended" (p. 252). Reliability refers to if other researchers conduct repeated examinations of the survey, the researcher should obtain the same results when conducted on the same population (Blair et al., 2014; Creswell, 2014).

Educator surveys. In the first phase of the research, a survey was given to purposefully selected teachers and leadership in the district to identify participants' understandings, perceptions, successes, and challenges of implementing the STEM innovation. The survey instrument used to gather data as designed for this study's research centered around four ideas of the literature review; therefore, Creswell (2014) argued the research study needed to convey steps taken "to check for accuracy and credibility of [the] findings" (p. 201). Both the teacher and leadership surveys were developed by the researcher. Based on suggestions from Blair et al. (2014), the researcher conducted her own evaluations and revisions of both surveys; however, to establish validity and reliability, a panel was formed to perfect each survey using feedback from teachers and leadership. Panel members than conducted pretesting of the survey to determine sampling and time.

Teacher survey. A panel of seven educators convened to review the developed survey. Each panel member was an educator trained in the STEM innovation and was familiar with implementation of an innovation. Panel members revised, evaluated, and clarified survey items so respondents "will understand questions, know the answers, and be willing and able to give the answers" (Blair et al., 2014, p. 234). The panel reviewed

teacher survey items are included in Appendix B.

Leadership survey. A panel of four leadership educators convened to review the developed survey. Each panel member was an educator trained in leadership as well as the STEM innovation and was familiar with implementation of an innovation. Panel members revised, evaluated, and clarified survey items. The leadership survey review paneled items are included in Appendix C.

Focus group sessions. Creswell (2014) noted that in mixed methods research, the study originates with a survey to gain an understanding of the population and then follows the survey with open-ended interviews to gather detailed opinions from participants to explain the initial survey results. Kitzinger (1995) recommended focus group sessions to gather open-ended interview data to benefit from the shared experiences of participants; therefore, the goal of employing focus group sessions was to provide clarified explanations of the survey data. Each member of the focus group, between six and 10 participants (Creswell [2014] suggested between six and eight participants), were chosen randomly from those volunteering to be part of the sessions (Morgan, 1997).

Furthermore, the focus group sessions were recorded and transcribed. An observer and notetaker also served as an outside participant and recorder in the focus group sessions. This individual observed and recorded detached open-ended narrative observations, along with the researcher's detached open-ended narrative observations. These observations were utilized to allow the researcher to recall the people involved and the things that attracted attention while those being interviewed answered questions (Glickman et al., 2018).

Additionally, the focus group sessions expanded upon the four ideas found in the literature review and the survey. As with the survey, a panel of educators reviewed the focus group questions to revise, evaluate, and clarify the questions.

***Teacher focus group items*.** A panel of seven educators convened to review the developed focus group questions. As with the teacher survey panel, each teacher focus group panel member was an educator trained in the STEM innovation and was familiar with implementation of the innovation. Panel members revised, evaluated, and clarified survey items so respondents "will understand questions, know the answers, and be willing and able to give the answers" (Blair et al., 2014, p. 234). The focus group interview protocol for teachers review paneled items are included in Appendix D.

Leadership focus group items. A panel of four leadership educators convened to review the developed focus group questions. Each panel member was a leadership educator trained in the STEM innovation and was familiar with implementation of an innovation. Panel members revised, evaluated, and clarified survey items. The focus group interview protocol for school leaders review paneled items are included in Appendix E.

Analyzing the Data

Creswell (2014) documented that when analyzing data in an explanatory sequential mixed method design study, quantitative and qualitative data are examined separately. Quantitative data are reported first, then qualitative data are coded for themes. Additionally, a third phase, according to Creswell (2014), is conducted when analyzing research data. In the third phase, the researcher uses the qualitative data to provide in-depth explanations of the quantitative findings.

Educator survey data analysis. Each educator survey was conducted using the online format of Survey Monkey. In using this format, Likert scale items, multiple response listed responses, Dichotomy responses questions, and closed questions were used to present descriptive statistics. These descriptive statistics were analyzed independently and percentage frequency distributions were presented. Mode was used to measure central tendency in Likert scale items. The open response survey items were also analyzed independently; however, items were coded and explored.

Focus group data analysis. As explained, focus group sessions were used to provide in-depth explanations of the quantitative findings (Creswell, 2014). Butin (2010) acknowledged the use of focus groups allow participants to examine their perspectives in the form of a narrative response. Once a focus group session was completed, the researcher used recommendations from Creswell (2014) to complete analysis. Creswell (2014) recommended analyzing qualitative data using a linear, hierarchical approach. Figure 4 displays Creswell's (2014) linear, hierarchical approach to data analysis in qualitative research.

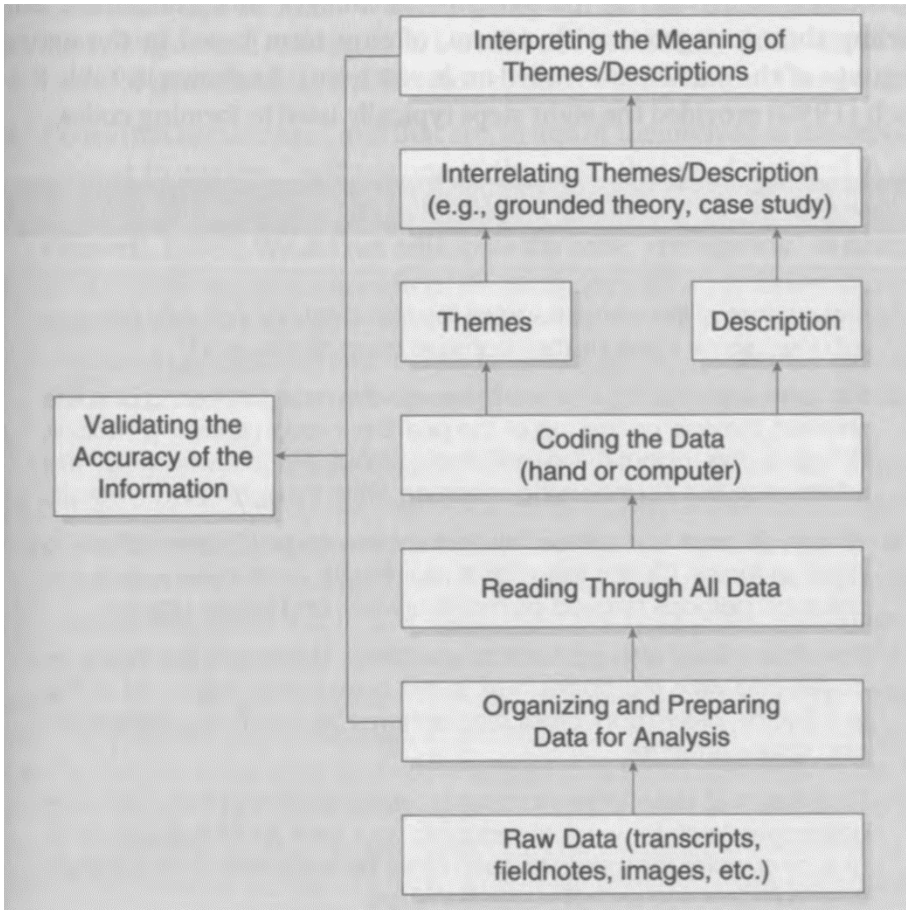


Figure 4. Creswell's (2014) Data Analysis in Qualitative Research. This linear, hierarchiacal approach to data analysis was used to analyze focus group data.

In step one, focus group data were transcribed and observation/notes were typed and sorted, arranging data into "sources of information" (Creswell, 2014, p. 197). In step two, the researcher examined all the data to gather a sense of what the information is describing (Creswell, 2014). In the third step, coding began. Coding, according to Creswell (2014), is when the researcher organizes the data into themes. "It involves taking text data or pictures gathered during data collection, segmenting sentences (or paragraphs) or images into categories, and labeling those categories with a term, often a term based in the actual language of the participant" (Creswell, 2014, p. 198). In step

four, the researcher used the coding procedure to produce an account of the environment of the sessions from the detached open-ended narrative notes. In step five, the researcher used a narrative to portray the findings of the focus group analysis. In the final step, the researcher made an interpretation of the findings and defined the meaning of how it impacted the quantitative data findings.

Summary

Research revealed a demand for STEM professionals was anticipated to expand 17% between 2008 and 2018 (Langdon et al., 2011); however, Rockland et al. (2010) expressed this increase will create a shortage of STEM workers needed to propel the nation's economic advancement, mainly because many students are not attracted to STEM related fields of study (Rockland et al., 2010). This revelation has led to legislative acts aiming to increase STEM education in public schools over the years. Hence, many educational institutions are emerging focusing on support for the innovation; however, most specialized educational institutions centering around the STEM innovation are found in the secondary level. Many elementary schools do not utilize the innovation even though these organizations understand science literacy starts in early childhood (Cafarella et al., 2017; Worth, 2010). Additionally, these organizations understand the benefits the innovation provided for student real-world understanding (Cafarella et al., 2017; Worth, 2010); however, time for the innovation is not provided adequately and is actually decreasing (Blank, 2013; Cafarella et al., 2017).

Those elementary institutions that are promoting the implementation of the STEM innovation can prepare other elementary institutions considering specializing in the innovation. Through a postpositivist paradigm, explanatory sequential mixed methods

design, this research investigated elementary educator perceptions and understandings, including strengths and challenges associated with implementation of the STEM innovation, inside three demographically diverse district elementary schools. The study also gathered information concerning to what extent elementary educators were supported through the implementation process as well as how the innovation could have been supported in the elementary classroom to make the process flow smoothly. In conducting the research, quantitative and qualitative data were collected during two phases. In the first phase, data were collected from a researcher-created survey. Once the survey results were analyzed, focus group sessions were conducted to gain an understanding of the survey results.

Chapter 4: Results

Review of Problem Statement

Educators are responsible for developing and nurturing students' educational interests as well as assisting them in succeeding in a global world. In order to meet this demanding responsibility, many secondary schools are utilizing STEM education (DeJarnette, 2012; Murphy & Mancini-Samuelson, 2012); however, many elementary schools do not utilize the innovation which requires students to develop problem-solving skills to solve challenging problems, collect and assess evidence, and analyze the information to prepare them for success and knowledge needed to continue into the future (U.S. Department of Education, Office of Innovation and Improvement, 2016). Unlike traditional classrooms, the STEM classroom is designed to be integrated and interdisciplinary. Research has shown educators had little or no direction in how to switch their instructional practices from traditional learning into interdisciplinary STEM learning (Epstein & Miller, 2011). The interdisciplinary approach to instruction needed in STEM education has led many elementary educators not to feel confident in their understanding of the innovation (Epstein & Miller, 2011; Marx & Harris, 2006). Milgrom-Elcott and Blackwell (2016) warned that lack of STEM understanding had led elementary educators to feel concerned about teaching STEM even though support from the innovation is found at the national level.

Statement of Research Focus

The National Research Council (2007) acknowledged the economies of the nation and world are becoming dependent on the skill sets of those in the science and engineering world. Additionally, the North Carolina STEM Center (2018) recognized

maintaining scientific and technological leadership is vital for the economy, security, and future of the state; therefore, many schools across the nation responded by implementing STEM instructional practices to meet the needs expressed by political decrees (Lang, 2017; The State of the Union Address, 2011). However, STEM practices have predominantly received attention in secondary education (Murphy & Mancini-Samuelson, 2012), even though it is argued students in the elementary grades are at the best age to become motivated and make connections to STEM fields (DeJarnette, 2012).

Elementary educators understand the importance STEM practices have on students' creativity and understanding of real-world problems. They understand students learn and retain information when many parts of the brain are active in activities that encourage movement, talking, and listening (Dodge & Duarte, 2017); however, many educators lack confidence in their understanding of the interdisciplinary approach to teaching STEM innovation requires (Williams, 2016).

Even though this lack of confidence has resulted in many educators being unable to shift their mindsets to understanding prepared for the STEM innovation, it is seen as one way to implement a high-quality education for students (National Research Council, 2007); therefore, this mixed methods research study aimed to investigate elementary educators' perspectives of implementing the STEM innovation in three demographically diverse district elementary schools as well as characterize successes and challenges associated with implementing the STEM implementation as a means of determining to what extent elementary educators are prepared in implementing the STEM innovation. To aid in answering the primary question, five hybrid quantitative and qualitative data research questions were addressed.

1. How can elementary educators' perceptions and understandings of the STEM innovation be described?
2. To what extent are STEM instructional practices being implemented?
3. How do elementary educators characterize successes and challenges in implementing the STEM innovation?
4. To what extent are elementary educators supported in their implementation of the STEM innovation?
5. How could the STEM innovation be further supported in the elementary classroom?

Chapter Overview

The formerly mentioned hybrid research questions were utilized to structure the findings of this chapter. Particularly, this study used a mixed methods approach to determine quantitative and qualitative findings related to the overall question examining the extent to which elementary educators are prepared in implementing the STEM innovation. This chapter provides a review of each of the five research questions as well as the data analyses related to each question. The data analyses are specified and described for each question through the use of figures as well as narrative descriptions. As mentioned previously, the research focused on STEM implementation in three demographically diverse schools within a district. The researcher used both teachers and leadership perspectives to gain an understanding of their perspectives of implementing the STEM innovation.

Presentation of Results

Educator perceptions and understanding of STEM. Research Question 1,

"How can elementary educators' perceptions and understandings of the STEM innovation be described," was shaped to address the interpretation of STEM terms for the educators involved in the study. Through this research question, the researcher acquired an understanding of how STEM education is described and how it relates to education for the different educators at the three researched schools. To gain this understanding, the researcher collected quantitative data from a teacher survey and a leadership survey as well as qualitative data from teacher and leadership focus groups.

This question's importance in the study finds its roots in the development of STEM education and in confusion over its meaning. As previously identified, in the 1990s, the National Science Foundation created the STEM acronym to combine strengths of scientists, technologists, engineers, and mathematicians, in the hope of generating a sounder political voice (STEM Task Force Report, 2014). The acronym established an understanding of the four fields based on the incorporation of inquiry-based learning focusing on real-world concepts through an active learning approach (STEM Task Force Report, 2014). However, a problematic argument exists for researchers involved in STEM education; STEM itself has a plethora of explanations and descriptions (Burke et al., 2014; English, 2016; Honey et al., 2014; Moore & Smith, 2014; Rennie et al., 2012; Vasquez, 2015; Vasquez et al., 2013).

North Carolina expansively defined STEM as well, defining the term as, "an infusion of Science, Technology, Engineering, and Mathematics through project-based learning to understand complex problems and to prepare our next generation of innovations" (Public Schools of North Carolina, n.d.c, para. 1). These definitions lead to many interpretations of the term and could influence educators' perceptions of STEM

education (Brown et al., 2011; Stansbury, 2011).

Survey data. An educator survey was made available for 3 weeks to all teachers and leadership members of each of the three schools during October. Both surveys included the same questioning and asked respondents to describe in their own words their perceptions and understandings of the terms STEM, inquiry-based learning, engineering design process, active learning, and Next Generation Science Standards. The surveys also asked respondents to identify three critical reasons to implement STEM innovation in the elementary classroom.

Perceptions and understandings of the term STEM. Prior to educators receiving the survey, the researcher used numerous definitions of STEM as well as the literature review to guide the development of the survey to address this research question focused on understanding educator perceptions. After developing the survey, the researcher met with a panel of teachers and leaders to align developed questions with the goal of the research question to address understanding and perceptions of STEM education in the elementary classroom. Additionally, dissertation committee members reviewed the surveys and added the understanding of Next Generation Science Standards to gain an understanding of current perceptions of national standards that guide student experiences and expectations, while preparing them for life beyond the classroom (Next Generation Science Standards, n.d.). Table 12 displays the alignment between the surveys and the STEM innovation.

Table 12

Educator Survey Alignment to STEM Innovation

STEM Innovation Component	Aligned Items in Teacher Survey	Aligned Items in Leadership Survey
STEM Description	23 (open-ended)	22 (open-ended)
Reasoning to Implement in Elementary Classroom	24 (multiple response)	23 (multiple response)
Inquiry-Based Learning Description	25 (open-ended)	24 (open-ended)
Engineering Design Process Description	26 (open-ended)	25 (open-ended)
Active Learning Description	27 (open-ended)	26 (open-ended)
Next Generation Science Standards Description	28 (open-ended)	27 (open-ended)

Table 12 displays six aligned questions found on both the teacher and leadership surveys. Open-ended questions were used to gain an understanding of the respondents regarding their current understanding and perceptions of the STEM innovation. One multiple response question was used to determine respondents' top three important reasons to implement the innovation in the elementary classroom. The following shared results for Research Question 1 can be found in a tabular format. Additionally, each open-response item is coded and sorted into themes and descriptions. Responses not common are categorized as other. Responses supporting "other" are elaborated upon following the figures. Table 13 presents common coded responses for the survey question "In your own words describe STEM."

Table 13

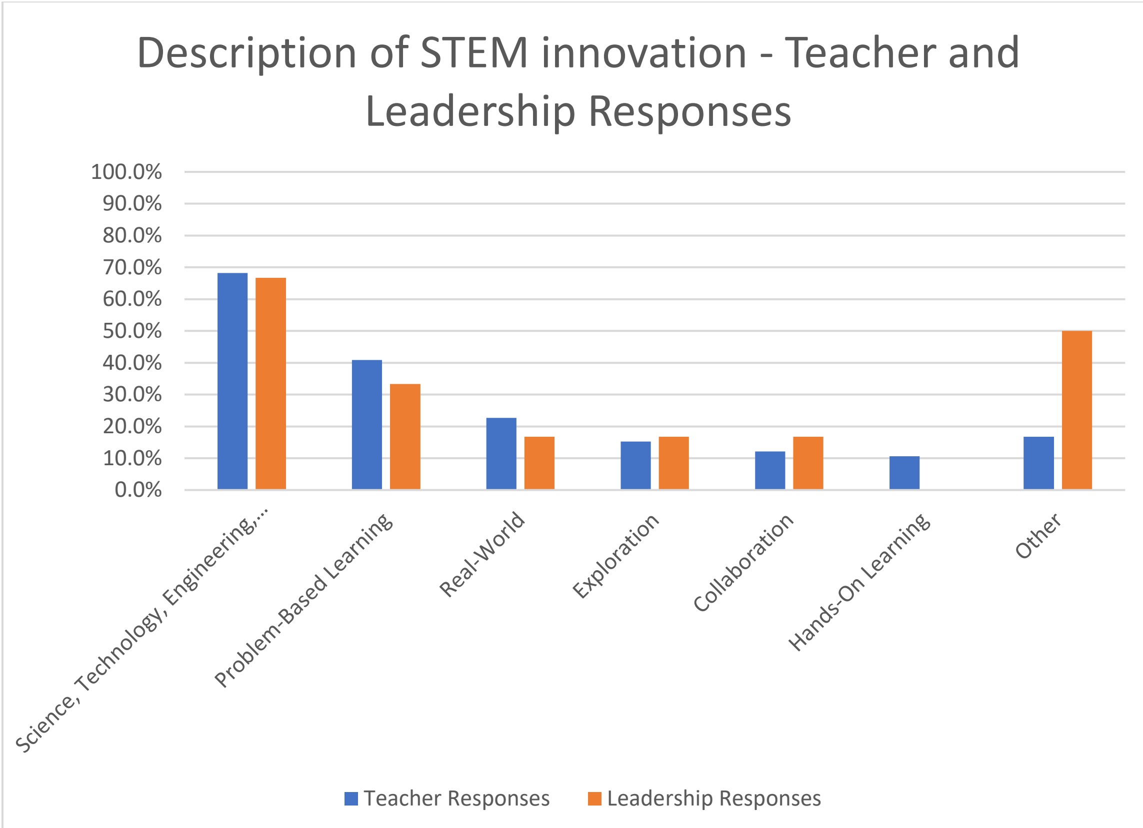
Common Themes Found in STEM Description

STEM Description	Coded Variable
Science, technology, engineering, and mathematics	Science, technology, engineering, and mathematics
Inquiry-based or problem-based learning	Problem-based learning
Real-world applicable	Real-World
Students use exploration to solve problems	Exploration
Students work with others	Collaboration
Hands-on learning	Hands-on learning
Other	Other

The question, "In your own words describe STEM," required respondents to provide their current understanding of the STEM innovation; therefore, the question was presented in an open-ended platform. To provide quantitative descriptive data, interpretation of open-ended responses occurred. This interpretation involved several steps in determining trends in data. The researcher first read all open-ended answers and identified themes. Next, the researcher categorized each response into an identified response (Creswell, 2012). Since the STEM innovation involved many interpretations, a response might contain more than one identifiable theme. A standard description of identifying the STEM innovation was found in the description of science, technology, engineering, and mathematics.

Along with this description, some respondents elaborated on their understanding of the innovation to include inquiry- or problem-based learning. Inquiry-based learning assimilates attaining knowledge from observing and being active in the learning process (Oguz-Unver & Arabacioglu, 2014). Problem-based learning uses inquiry through

investigating and acquiring knowledge (Oguz-Unver & Arabacioglu, 2014); however, problem-based learning also includes inquiry-based learning "when students are active in creating the problem" (Oguz-Unver & Arabacioglu, 2014, p. 122). Therefore, these two terms were linked to a common theme. Respondents also mentioned STEM involving an applicable real-world design. Since inquiry and problems can deal with more than just real-world themes, a separate theme was utilized for these responses. Many respondents also mentioned exploration in their description students learn through an exploratory process. Since collaboration is a component of the STEM innovation and many respondents mentioned this theme in their response, this idea was also developed into a theme. Numerous respondents also touched upon the topic of hands-on learning. Even though hands-on learning is a component of active learning, many respondents just mentioned hands-on learning using an instructional and experiment design and did not mention other components of active learning; therefore, hands-on learning was developed into a theme. A few respondents did not mention science, technology, engineering, or mathematics or answer in a way in which their responses could be placed into a theme; therefore, these responses were given the response of "other." After analysis of quantified identified themes, descriptions involving "other" category are presented. Figure 5 explores frequencies of both teacher and leadership responses for each of the elementary schools involved in the study involving the personal description of the STEM innovation.



Note. Three teacher respondents chose not to answer survey item resulting in 4.3% of missing cases.

Figure 5. Description of STEM Innovation. This figure presents quantitative data frequencies depicting teacher and leadership description of STEM innovation.

Figure 5 shows teacher and leadership respondent frequencies involving descriptions of STEM innovation. Quantitative analysis revealed teachers and leadership respondents have similar understandings of STEM innovation. The majority of both teacher and leadership respondents responded STEM involves the four discipline areas of science, technology, engineering, and mathematics. Fewer respondents were able to identify STEM as involving inquiry (problem-based) learning. Only 40.9% of teachers and 33.3% of leaders were able to identify this component. Even fewer respondents could describe other elements of STEM. These findings are supported by the National Academies of Sciences, Engineering, and Medicine (n.d.) which reported members of the

committee were unable to succeed in determining a definition summarizing STEM education.

As previously mentioned, some teacher respondent descriptions of STEM innovation could not be categorized with a commonly found theme; therefore, these responses were coded as “other.” Table 14 depicts teacher responses coded as “other.”

Table 14

Teacher Description of STEM “Other” Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
Think critically, interdisciplinary, and engineering and design cycle	Trying multiple times, science, old fashioned, successful, change in mindset, preparing students to be thinkers, and effective	Become leaders, successful, transform, and growth mindset

Table 14 describes teacher responses coded as “other.” Three teacher respondents at Heritage Elementary included information not identified with a common variable. Two respondents mentioned STEM involves incorporating all subjects, and a third respondent described STEM involving the use of the engineering and design cycle. In addition to these three “other” coded descriptions, Old Mountain Elementary expressed six additional responses classified as “other.” One respondent provided STEM allows students to try multiple times if their solution does not work. A second respondent mentioned the innovation involves the exploration of science concepts; and a third respondent described the innovation as being old fashioned, something that they grew up learning. Also, a fourth respondent responded the innovation involves a change in mindset, one that prepares learners to be successful citizens. The fifth respondent described the innovation as preparing students to be thinkers, and the sixth respondent defined STEM as being effective. Furthermore, two teacher respondents at Louis Armstrong Elementary provided descriptions of the STEM innovation not identified with

a common variable. One respondent described the innovation as having the power to transform classrooms by providing opportunities for students to become leaders. The respondent also stated that the innovation prepares students to become successful in the jobs of tomorrow.

Additionally, three leadership respondents' descriptions of the innovation could not be categorized with a commonly found theme; therefore, these responses were coded as "other." Table 15 depicts leadership responses coded as "other."

Table 15

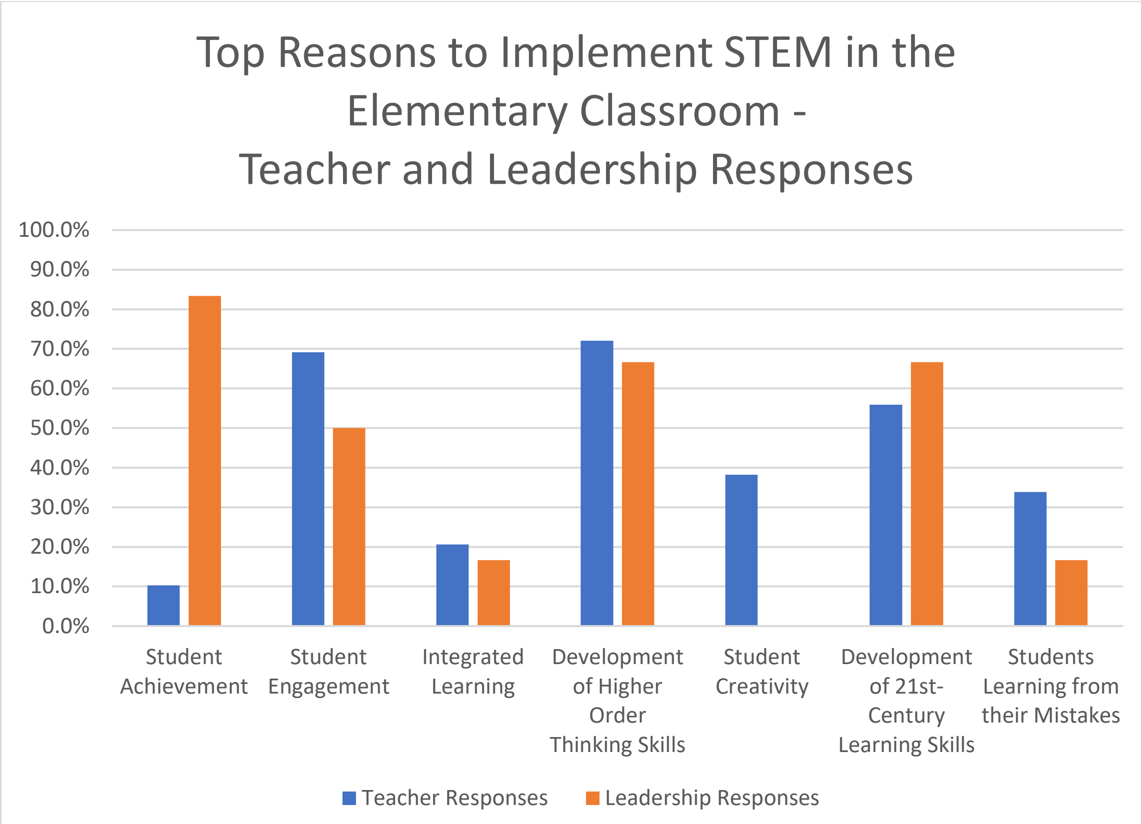
Leadership Description of STEM "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
No "other" responses identified	Preparing students for careers and colleges, innovative, critical thinking, and rigor	Connecting skills and career connections

Table 15 displays leadership descriptions of the STEM innovation coded as "other." Only three respondents from two elementary schools included descriptors not identified with a common theme. Both respondents at Old Mountain Elementary expressed further understanding of the term STEM. One respondent included STEM is responsible for preparing students for careers and colleges. Similarly, the other member of Old Mountain's leadership team described STEM as innovative, authentic, engaging instruction that leads to critical thinking and rigor. The respondent at Louis Armstrong Elementary expressed STEM includes connecting skills and career connections.

R*easons to implement STEM innovation in an elementary classroom.* In addition to determining how teachers and leaders defined STEM as an innovation, Research Question 1 focused on perceptions related to the importance of implementing STEM in elementary classrooms. North Carolina believes STEM education is needed to encourage

financial growth and revenue for the state (Public Schools of North Carolina, n.d.b). The elementary years, according to Kroeger (2016), provide an opportune time to invest in the STEM foundation; however, many educational institutes implementing the innovation are in the secondary education sector. Figure 6 displays information related to teacher and leadership views regarding reasons to implement the STEM innovation in the elementary setting.



Note. One teacher respondent chose not to answer survey item resulting in 1.4% of missing cases.

Figure 6. Top Reasons to Implement STEM in the Elementary Classroom. This figure presents quantitative data frequencies depicting teacher and leadership top three reasons to implement STEM in the elementary classroom.

As shown in Figure 6, teachers and leaders differed slightly when describing the top three reasons to implement STEM in the elementary classroom. Quantitative analysis revealed the top three reasons provided by teachers to implement STEM in the

elementary classroom consisted of student engagement, development of higher order thinking skills, and development of 21st century learning skills. In addition, the top three reasons provided by leaders to implement STEM in the elementary classroom consisted of student achievement, development of higher order thinking skills, and development of 21st century skills.

Perceptions and beliefs involving STEM-based instructional practices. In addition to determining why STEM should be implemented in the elementary classroom, Research Question 1 also focused on educator understanding of STEM-based instructional practices. STEM involves many components; therefore, many educators have a difficult time comprehending what instructional practices are needed to encourage growth with the innovation. Nonetheless, a few research-based instructional practices can be explored to encourage student understanding and knowledge growth of STEM literacy (Vega, 2012).

One of those instructional practices includes inquiry-based learning through real-world application. Bulba (2015) noted that when educators incorporate inquiry-based teaching, students develop science literacy through an investigative process. As previously mentioned, the National Research Council (1996) stated inquiry-based practices create learners who (1) are “engaged by scientifically oriented questions,” (2) give “priority to evidence,” (3) express “explanations from evidence,” (4) assess “explanations in light of alternative explanations,” and (5) “communicate and justif[y] proposed explanations” (p. 25); however, inquiry-based practices do not encompass a specific instructional practice (Keys & Bryan, 2001). Therefore, educators can have multiple interpretations of what inquiry-based learning entails.

Keeping in mind inquiry-based practices do not encompass a specific learning practice, the research aimed to gather elementary educator perceptions and beliefs of inquiry-based learning. Educators were tasked to define what inquiry-based learning means to them; therefore, these open-ended responses were categorized into common themes. Table 16 presents common coded responses for descriptions of inquiry-based learning.

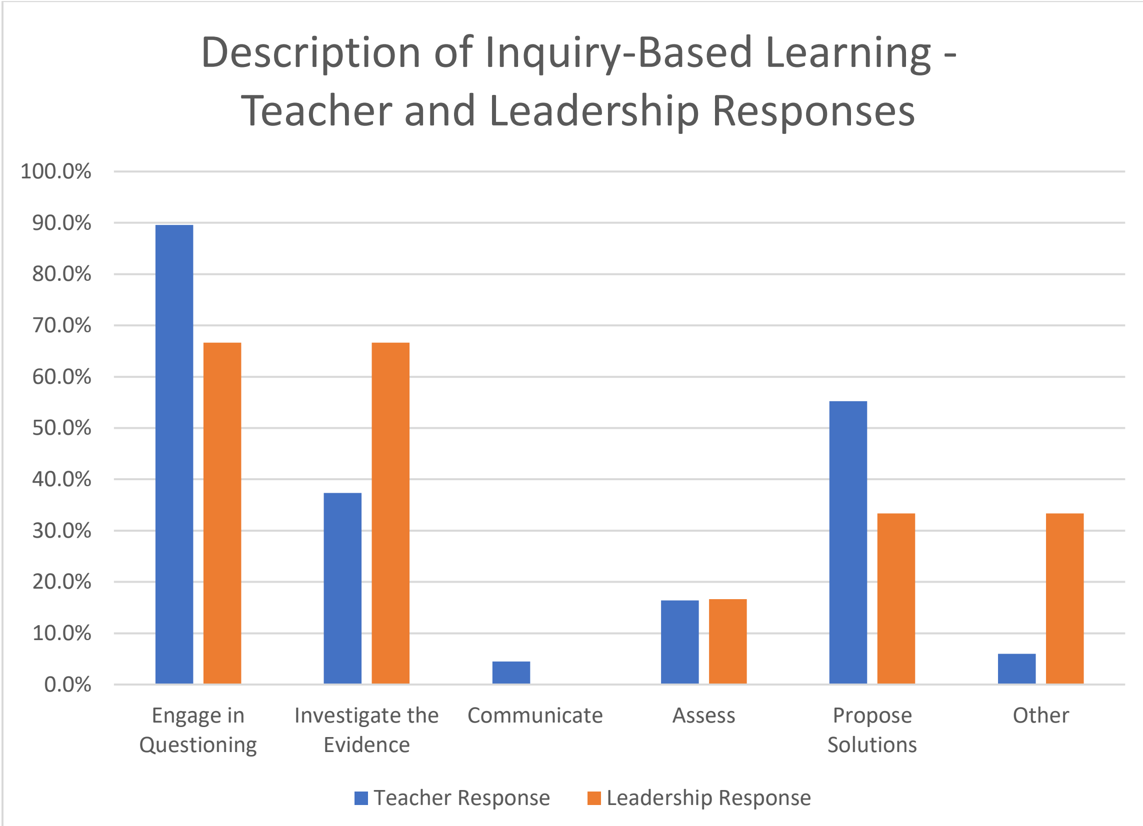
Table 16

Common Themes Found in Inquiry-Based Learning Description

STEM Description	**Coded Variable**
Engaged in questioning, problem-solving, and critical thinking	Engage in Questioning
Students investigate the evidence, explores through learning, is engaged in the process, and is learning through discovering	Investigate the Evidence
Students explain their reasoning, students communicate	Communicate
Students assess or evaluate	Assess
Students propose solutions or draw conclusions from their inquiry	Propose Solutions
Other	Other

Table 16 displays common themes found within educator descriptions of inquiry-based learning. Six different themes were identified: engage in questioning, investigate the evidence, communicate, assess, propose solutions, and other. The theme identified as “other” includes noncommon themes found within responses. The addition of this variable is explained after frequency data are discussed. Additionally, multiple responses may include more than one identified theme; therefore, some respondents’ descriptions are placed into multiple identified themes. Figure 7 depicts percentage frequency for

categorized themed data.



Note. Two teacher respondents chose not to answer survey item resulting in 2.9% of missing cases.

Figure 7. Teacher and Leadership Descriptions of Inquiry-Based Learning. This figure presents quantitative data frequencies depicting teacher and leadership descriptions of inquiry-based learning.

Figure 7 displays teacher and leadership understandings of inquiry-based learning. As mentioned previously, inquiry-based learning involves many components. These different components were viewed in respondent understanding. Quantitative data analysis revealed the majority of respondents understand inquiry-based learning involves engagement in questioning; this would seem to stem from the connection between inquiry and questioning. However, the identified common theme of investigate evidence was expressed in fewer teacher respondents' descriptions. STEM focuses on investigating

and exploring; however, this focus was not provided in many teachers' or leaders' understanding of the practice. Also, inquiry-based learning fosters curiosity and provides students a way to gather information, critique and analyze the information, and pose additional questioning in a setting that supports collaboration (U.S. Department of Education, Office of Innovation and Improvement, 2016). Nonetheless, these supports were mentioned by fewer teacher respondents.

In addition, four teacher respondents' descriptions of inquiry-based learning could not be categorized with a commonly found theme; therefore, these responses were coded as "other." Table 17 depicts teacher responses coded as "other."

Table 17

Teacher Description of Inquiry-Based Learning "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
No "other" responses identified	Hands-on experimentation, taking items and solving a problem, involves learning skills and content that are required by the NCSCOS, and thought-provoking	No "other" responses identified

Table 17 displays teacher responses coded as "other" for descriptions involving the understanding of inquiry-based learning. Data analysis revealed four teacher respondents at Old Mountain Elementary provided understanding of the term classified as "other." These respondents expressed information consistent with inquiry-based learning; however, the provided understanding of the term differed from other respondents' understanding.

Additionally, two leadership respondents' descriptions of inquiry-based learning could not be categorized with a commonly found theme; therefore, these responses were coded as "other." Table 18 depicts teacher responses coded as "other."

Table 18

Leadership Description of Inquiry-Based Learning "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
Using background knowledge and students solving a problem relevant to them	No "other" responses identified	Collaborating to find possible solutions by following a model of observing, working, and reflecting

Table 18 displays leadership responses coded as "other" for descriptions involving the understanding of inquiry-based learning. Only two respondents responded with an understanding of inquiry-based learning not found with a common identifiable theme. Both respondents included understanding related to problem-solving. Since both respondents provided additional understanding not identified with a common coded variable, an additional theme of "other" was placed on the responses.

In addition to educators defining their understanding of inquiry-based learning, teachers and leaders also examined their understanding of the engineering design process. This additional research-based instructional practice can be used to encourage student understanding of STEM literacy. Created in 1973, this process is based on the work by Dr. Bernard Roth, who revealed engineers often find solutions to problems, only to find improved clarifications after additional thought (Roth, 1973); therefore, he described a design process that could be implemented to recount how engineers could effectively go through steps to think critically on how to solve a problem (Roth, 1973). In EDP, students are introduced to the concept of engineering and how it relates to math and science. Hill-Cunningham et al. (2018) acknowledged EDP allows students to become involved in how to solve problems. Respondents examined their understanding of EDP in an open-ended formatted item; therefore, an explanatory schema needed to be developed to identify common themes found in the numerous responses (Foss & Waters,

2007). To develop a list of common themes, the researcher used the EDP model (Figure 2). This model provided the sequence of steps engineers take to construct possible solutions to problems (Science Buddies, 2018). Table 19 describes common themes developed with aid from the EDP model.

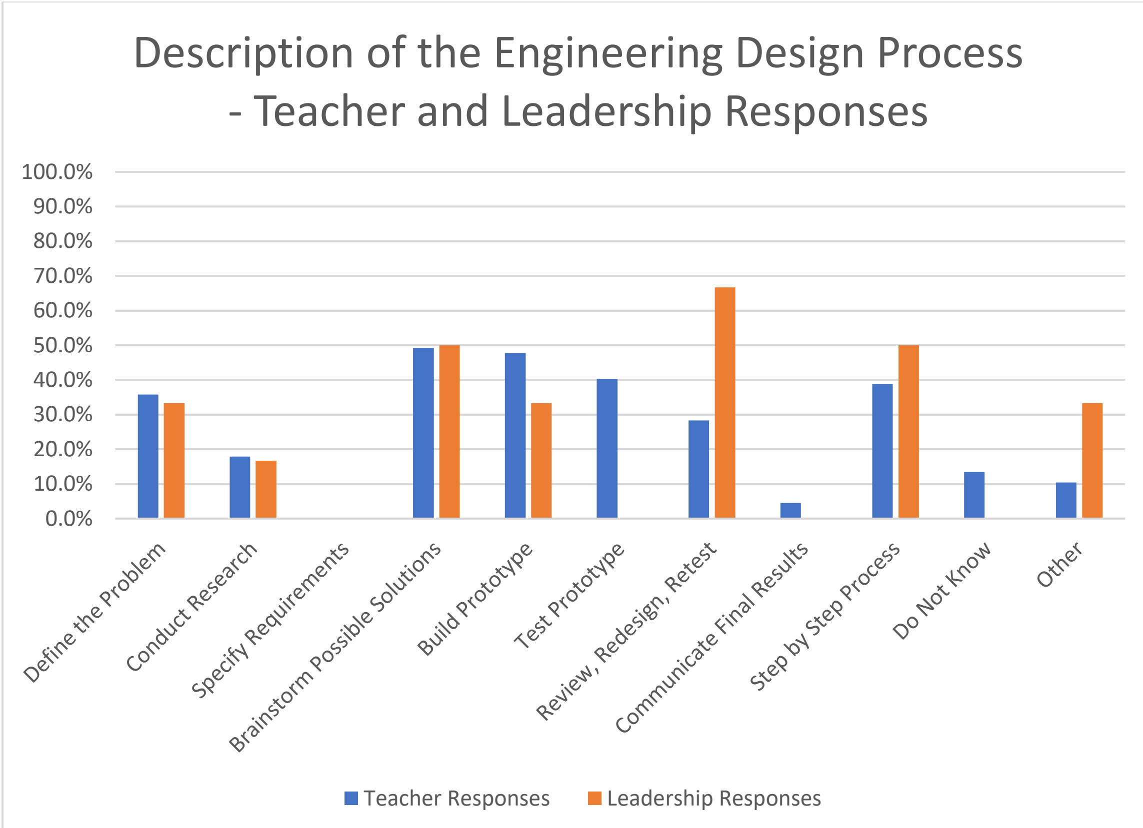
Table 19

Common Themes Found in EDP Description

Engineering Design Process Description	Coded Variable
Define the problem, real-world inquiry	Define the Problem
Conduct research, make observations, includes background research, learning from others, preventing mistakes others have made	Conduct Research
Specify requirements, limitations, delimitations, necessary specifications, requirements of clients	Specify Requirements
Brainstorm possible solutions, how could it be solved, team members collaborate on possible solutions, different perspectives are heard, choose the best solution, explore design solutions, planning	Brainstorm Possible Solutions
The building of prototype, developing prototype, hands-on construction, rough design, creating solutions, solving the problem	Build Prototype
Testing possible solutions, learning from mistakes	Test Prototype
Redesigning based on the test, notes improvements, reflects upon the process, considers feedback, refinements	Review, Redesign, Retest
Communication of final results, report findings	Communicate Final Results
Process, step-by-step, cycle, series of steps	Step-by-Step Process
Don’t know, not familiar	Do Not Know
Other	Other

Table 19 provides common themes used by educators to describe EDP. Using the EDP model as support for understanding, a series of eight different themes were identified: define the problem; conduct research; specify requirements; brainstorm

possible solutions; build prototype; test prototype; review, redesign, and retest; and communicate final results. However, no respondents were able to identify the component of specifying requirements as an aspect of EDP. Still, the coded variable was left as an identifiable marker to gain an understanding of the term as a whole since the step is part of the EDP model. Additionally, three other themes were explored based on responses. These additional identifiable themes are step-by-step process, do not know, and other. Many respondents included the understanding of EDP as being conducted through a series of events or steps. Also, some respondents specifically stated they do not know what this STEM instructional practice entails. Furthermore, some respondents' descriptions included an understanding not identified with a shared variable; therefore, the variable of "other" was placed on these descriptions of the process. Responses coded as "other" are described following the analysis and exploration of coded frequencies. Figure 8 depicts percentage frequency involving teacher and leadership respondent understanding of EDP.



Note. Two teacher respondents chose not to answer survey item resulting in 2.9% of missing cases.

Figure 8. Teacher and Leadership Descriptions of EDP. This figure presents quantitative data frequencies depicting teacher and leadership descriptions of EDP.

Figure 8 provides teacher and leadership description frequencies involving the understanding of EDP. Quantitative analysis revealed teachers and leadership respondents differed slightly in their understanding of EDP. Most teachers responded that inquiry-based learning involves brainstorming possible solutions as well as constructing (building) and testing of a prototype. Most leadership participants responded EDP consists of reviewing, redesigning, and retesting as well as brainstorming possible solutions while completing inquiry in a step-by-step process; however, EDP involves many elements, and both teachers and leaders were unable to describe each of these elements when describing their understanding of the practice. This discrepancy in

understanding can be attributed to a lack of understanding of the instructional practice.

Also, seven teacher respondents' descriptions of EDP could not be categorized with a commonly found theme; therefore, these responses were coded as "other." Table 20 depicts teacher responses coded as "other."

Table 20

Teacher Description of EDP "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
Having students connect activities to the real-world	Product must be functional, an organized way of thinking, and students are discussing and trying to figure out the problem	Design age-appropriate items in order to think like an engineer, the process is used by engineers, and it is the part of the problem where engineering is to be used

Table 20 displays coded "other" descriptions of teacher respondents' understanding of EDP. Each elementary school had respondents who provided an understanding categorized with "other." Some respondents connected their understanding of the instructional practice to a developed common code; however, the descriptors found in the table provided additional understanding of EDP.

Additionally, two leader respondents' descriptions of EDP could not be categorized with a commonly found theme; therefore, these responses were coded as "other." Table 21 depicts leadership responses coded as "other."

Table 21

Leadership Description of EDP "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
Trying out theories	No "other" responses identified	A problem-solving model

Table 21 displays coded "other" descriptions of leadership respondents' understanding of EDP. Only two respondents responded with descriptions of EDP not identified through a common theme. One leadership respondent expressed EDP involves

trying out theories. A second respondent provided the process contains a problem-solving model.

Along with the preceding instructional practices, teachers and leaders examined their understanding of active learning. As previously mentioned, innovation is an approach to academic learning that focuses on cultivating a student's creative self-confidence through an application of active learning, leading to the promotion of inquiry (Kwek, 2011). Active learning is a component of problem-based learning and EDP and is defined as using multiple intelligences (discussion, collaboration, critical thinking, problem-solving, and connection) to solve real-world problems and learning from these encounters (Rosicka, 2016). In active learning, students are in charge of their learning (Sirinterlikci et al., 2009); therefore, teachers must be facilitators and encourage students to learn and develop their knowledge (Rockland et al., 2010). Respondents examined their understanding of active learning in an open-ended formatted item; therefore, an explanatory schema needed to be developed. To develop a list of themes, the researcher used common descriptions of the term found in respondents' descriptions. Table 22 displays these common themes.

Table 22

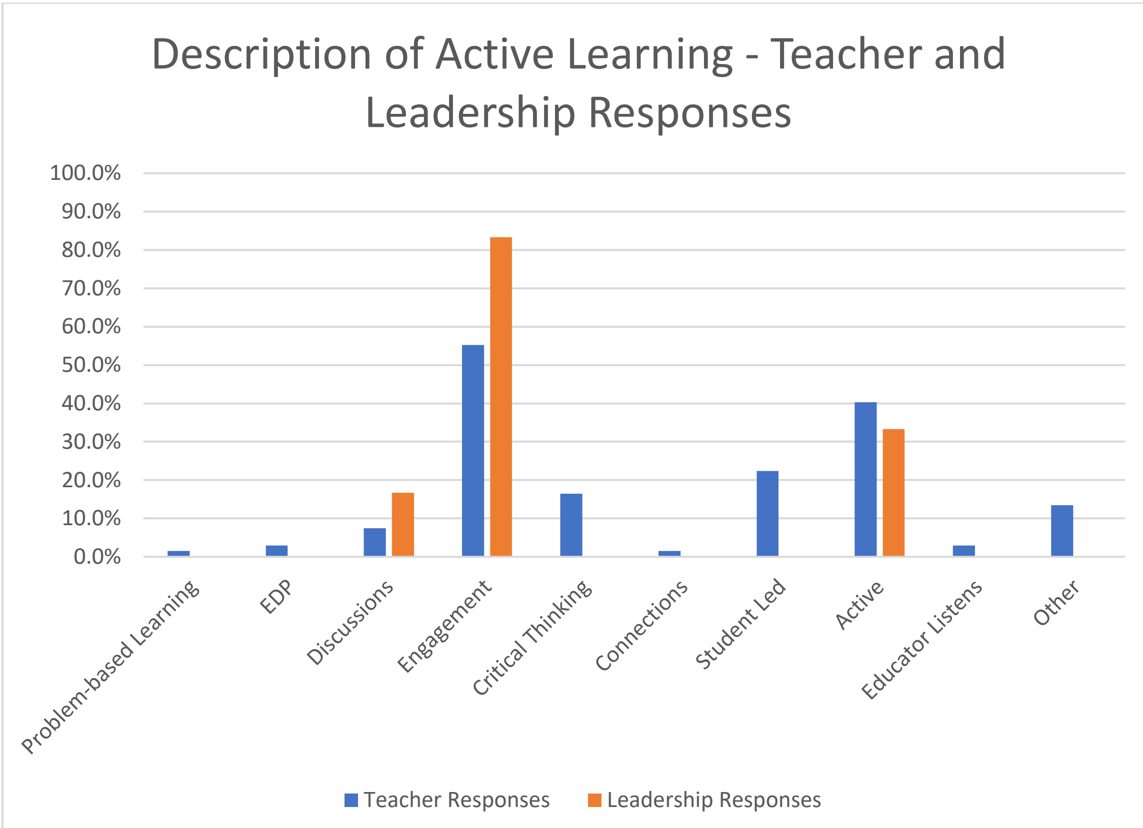
Common Themes Found in Active Learning Description

Active Learning Description	Coded Variable
Problem-based learning	Problem-based Learning
Engineering Design Process	EDP
Discussions, discussions involving different solutions, and sharing	Discussions
Collaboration, interacting with peers, engaged, engagement, working together, and learning with other students	Engagement
Critical thinking, problem-solving, real-world problems, and figuring out solutions	Critical Thinking
Making connections	Connections
Students are invested, students are responsible for their learning, student-led, student, focused, and student-centered	Student Led
Active, hands-on, physical, moving around	Active
Educator listens, the teacher is the facilitator	Educator Listens
Other	Other

Table 22 reveals common themes found in elementary educator descriptions of active learning; however, the researcher did include problem-based learning and EDP as a theme. These descriptions were included based on active learning stands as a component of problem-based learning and EDP. The identified themes (discussions, collaboration, critical thinking, connections, student-led, active, and educator listens) were included based on common language used by survey respondents. Also, the theme "other" was developed based on uncommonly found language used in a respondent's description of active learning. Responses coded as "other" are described following the analysis and exploration of coded frequencies. Since active learning could involve more than one identified theme, some participants' responses might have more than one

description.

Figure 9 depicts teacher and leadership respondent percentage frequency involving an understanding of active learning.



Note. Two teacher respondents chose not to answer survey item resulting in 2.9% of missing cases.

Figure 9. Teacher and Leadership Descriptions of Active Learning. This figure presents quantitative data frequencies depicting teacher and leadership descriptions of active learning.

Figure 9 reveals elementary teachers' and leaders' perceptions describing their understandings of active learning. Data analysis revealed teachers and leaders struggled in defining active learning and do not express a common language or understanding when describing the learning. Data analysis also revealed teachers and leaders differed in their

understanding of the learning. Most teachers replied active learning involved engagement and students learning actively. As can be seen in the figure, engagement was a common theme expressed by respondents; however, school leaders also differed in their understanding of the term as well, which may influence teacher understanding.

Additionally, nine teacher respondents' descriptions of active learning could not be categorized with a commonly found theme; therefore, these responses were coded as "other." Table 23 depicts teacher responses coded as "other."

Table 23

Teacher Description of Active Learning "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
Learn from mistakes, and students use hands-on learning activities; however, they also reflect on outcomes	Experimenting with real-life objects, learning that is fun, learning that you do not realize you are learning, working towards a goal, and not familiar with the term	Not certain what the term means

Table 23 provides "other" descriptors teacher respondents presented in their open-response understanding of the term active learning. All three elementary schools expressed further understanding of the term not identified with a common variable. Most respondents provided a definition of the term relating to active learning in some capacity; however, some respondents from different schools expressed they were not familiar with the term active learning and therefore could not provide understanding of the instructional practice.

In addition to educators describing their understanding of active learning, teachers and leaders also examined their understanding of Next Generation Science Standards. While these standards are not considered instructional practices, they do provide educators with standards in encouraging inquiry and active learning practices.

Specifically, Next Generation Science Standards were fashioned to eliminate educator habit of "teaching to the test" (National Science Teachers Association, 2014). Since teacher accountability is prevalent in public schools, many educators focus on state assessments and stray away from inquiry-based teaching in which students are to apply knowledge to learning situations (National Science Teachers Association, 2014). As mentioned previously, these standards "shift the focus from merely memorizing scientific facts to doing science-so students spend more time posing questions and discovering the answers for themselves" (National Science Teachers Association, 2014, para. 1). These standards include three elements (crosscutting concepts, science, and engineering practices) that encourage an interconnective understanding of science over many disciplines and grade levels (Next Generation Science Standards, n.d.).

Keeping these three elements in mind as well as why the standards were created, the researcher developed themes. In addition to these themes, the researcher created explanatory schemas based on elementary educator understandings and perceptions of the term; however, many elementary educators involved in the study were not familiar with the term. Therefore, another category of "not sure" was placed into the schema. Table 24 displays common themes used to describe elementary educators' understanding of Next Generation Science Standards.

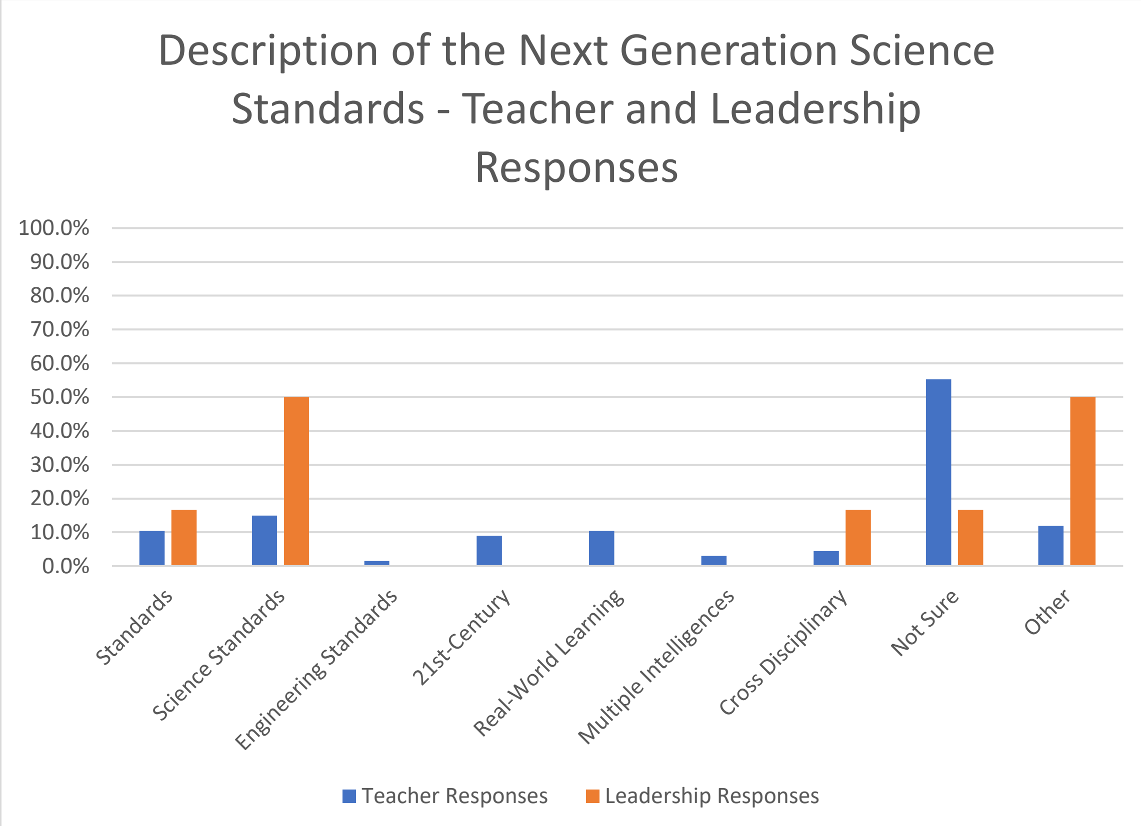
Table 24

Common Themes Found in the Next Generation Science Standards Description

Next Generation Science Standards Description	Coded Variable
Standards (not specific in their description)	Standards
Science standards	Science Standards
Engineering Standards	Engineering Standards
21^{st} century connections	21^{st} century
Real-World applicable, real-world inquiry, real-world learning, and real-world connections	Real-World Learning
Multiple Intelligences	Multiple Intelligences
Crosses disciplines and crosses grade levels	Cross Disciplinary
Not sure, cannot, and have only heard of them	Not Sure
Other	Other

Table 24 revealed common themes found in elementary educator descriptions of Next Generation Science Standards. Each of the developed themes were created based on an understanding of the standards as well as educator perceptions of the term. The identified themes (standards, science standards, engineering standards, 21^{st} century, real-world learning, multiple intelligences, and cross-disciplinary) were developed through these explanations; however, many elementary educator respondents also specified they were not sure what the standards consisted of; therefore, the researcher also included the theme of “not sure.” Also, the theme “other” was developed based on uncommon language used in respondents’ descriptions of Next Generation Science Standards. Responses coded as “other” are described following the analysis and exploration of coded frequencies. Since the Next Generation Science Standards could include more than one theme, some understandings were placed in more than one theme. Figure 10 depicts teacher and leadership respondent percentage frequency for categorized themed data

involving an understanding of Next Generation Science Standards.



Note. Two teacher respondents chose not to answer survey item resulting in 2.9% of missing cases.

Figure 10. Teacher and Leadership Descriptions of Next Generation Science Standards. This figure presents quantitative data frequencies depicting teacher and leadership descriptions of Next Generation Science Standards.

Figure 10 displays coded open-ended data involving elementary teacher and leadership understandings of Next Generation Science Standards. Quantitative data analysis revealed a lack of understanding in the standards. At all three elementary schools, the majority of teachers responded that they are unfamiliar with the standards leading to the common theme of “not sure.” Also, while some respondents replied they knew Next Generation Science Standards involved standards in some capacity, a consistant understanding of the standards was not in place for each of the elementary

schools. Also, quantitative analysis revealed that like elementary teachers, elementary leadership respondents also differed in their understanding of Next Generation Science Standards. Data analysis revealed leaders have different understandings of the standards. Three respondents revealed the standards involved science standards; however, this common theme was only expressed by two schools. Data analysis revealed school leaders lack a common understanding of the standards and the use of them.

Additionally, eight teacher respondents provided descriptions of Next Generation Science Standards not identified with a common theme. The descriptions categorized as "other" are explained in Table 25.

Table 25

Teacher Description of Next Generation Science Standards "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
Problem-solving application, address what a student should be able to do, and involves problem-based learning	Creating involves students needing a better understanding of how people affect the plant and how that affects their future on the planet and future generations, and make science standards more meaningful and updated	Science changing throughout generations

Table 25 provides "other" descriptors teacher respondents presented in their decription of Next Generation Science Standards. All three schools involved in the study expressed a few teacher respondents describing the standards with explanatory schema not supported by a common theme; however, the majority of these responses were found at Heritage Elementary. This inconsistent understanding of these descriptions can be attributed to a lack of understanding involving the standards.

Additionally, three leadership respondents provided descriptions of Next Generation Science Standards not identified with a common theme. The descriptions categorized as "other" are explained in Table 26.

Table 26

Leadership Description of Next Generation Science Standards "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
No "other" responses identified	Includes literacy standards	Centered around inquiry-based learning and the standards assist students in making connections that relate to how thinking is applied

Table 26 provides "other" descriptors leadership respondents presented in their open-response understanding of Next Generation Science Standards. Two schools expressed descriptors of the standards not identifed with a common theme. These descriptions do not provide a consistent understanding of Next Generation Science Standards; therefore, school leader understanding of the standards can impact teacher understanding of the standards.

Focus group data. Focus group sessions were conducted to gain an understanding of the opinions and perspectives of educators involved in the study. Three teacher focus group sessions were conducted at each of the elementary schools involved in the study to gain teacher understandings and perspectives of the STEM innovation. Additionally, leadership members were also able to participate in a focus group session held at a central location. All four focus group sessions involved questioning allowing for multiple perspectives to be observed, recorded, transcribed, and reviewed by the researcher. Responses from the focus group sessions relating to Research Question 1, "How can elementary educators' perceptions and understandings of the STEM innovation be described," revolved around two focus group interview protocol questions; however, an additional question was included after data analysis of the quantitative data occurred. This additional question was needed to gain an understanding involving if there should be

a standard definition of STEM education at the district level. Responses from each session revolved around the following concepts: current understanding of STEM education, opinions on implementing STEM education at the elementary level, and a standard definition of STEM education at the district level.

The first focus group question was rooted in the understanding of STEM education has different meanings to different people; therefore, the question was shaped to examine educator understanding of STEM education. Table 27 displays a quantitative breakdown of each focus group session for this focus group question.

Table 27

Quantitative Breakdown Focus Group Responses–STEM Education

Coded Theme	Referenced by Teachers	Referenced by Leadership	Total
Science, Technology, Engineering, and Mathematics	2	3	5
Real-world Application	2	2	4
Inquiry-based Learning	4	2	6
Collaboration	3	0	3
Active Learning	2	0	2
Other	2 (Interdisciplinary, Ownership, Retry/Relearn)	4 (Critical Thinking, Applying Knowledge. Aligned to Curriculum, Frame and Analyze)	6

Table 27 displays the quantitative breakdown of focus group responses focusing on educator understandings of STEM education. In analyzing focus group data, six themes emerged. These themes were science, technology, engineering, and mathematics; real-world application; inquiry-based learning; collaboration; active learning; and other. Some specific quotes supporting each of these themes are explored in Table 28.

Table 28

Focus Group Responses–Understandings of STEM Education

Coded Theme	Supporting Quote
Science, Technology, Engineering, and Mathematics	"My understanding of STEM is problem-based learning. Critical thinking centered around science, technology, engineering, and math."
Real-world Application	"I would say STEM to me is real life application, connected to the real-life problem-solving methods. Understanding how to frame and analyze something, how to apply your knowledge of that process to find potential solutions, and to improve something whether it be personal or professional. So, working through problem-solving. I would say career is certainly a piece of that. Helps motivate students and give them a goal that is related to science, technology, engineering, and math."
Inquiry-based Learning	"To me, it is another level of teaching to have an inquiry with the students and to focus on specific subjects like science, technology, engineering, and mathematics, all in one, but focusing on the inquiry and the process behind it and collaboration, working together."
	"Inquiry-based problem-solving skills… in which children are allowed to observe, work, and learn."
Collaboration	"Also, the huge importance of the collaborative element and realizing that sometimes students who do not excel academically in the traditional ways would excel here and that the children who do excel academically may not be as successful, but they can learn from the students who do not necessarily excel academically."
Active Learning	"I also see it as far as what I find beneficial is their trials of, if it does not work right the first time, it is not, "We are done. We failed." It is, "Let's put our heads back together and figure out how we can fix it and retry," and we talk about how scientists have to test and try things over and over and over again before they find the correct outcome if they ever do."
Other	"It is giving students control and ownership over their learning. They have more buy-in. They go and practice and they are engaged, and they are in charge of their own learning."

Table 28 provides some specific quotes supporting each of the identified themes connecting educator understandings of STEM education. These comments provide evidence that educators differed in their understanding of STEM education, which is consistent with not having a supported STEM definition.

With different perspectives of STEM education being expressed both

quantitatively and qualitatively, the researcher included a question not found in the focus group interview protocol. The question addressed, “Would it be beneficial for district schools to have a common definition of STEM?” Including this question allowed the researcher to gain a perspective involving the needs of those participating in STEM implementation. Table 29 displays a quantitative breakdown of each focus group session for this focus group question.

Table 29

Quantitative Breakdown Focus Group Responses–Standard District STEM Definition

Coded Theme	Referenced by Teachers	Referenced by Leadership	Total
Pro Standard District STEM Definition	7	0	7
Against Standard District STEM Definition, but Support for General Definition	5	4	9

As shown in Table 29, the quantitative breakdown of focus group responses focusing on a standard district STEM definition can be viewed. Quantitative focus group break down revealed more teachers prefer a standard district STEM definition; however, leadership participants are against a standard district STEM definition, though they do support a general definition of STEM to be developed. Table 30 displays some specific quotes from each focus group session addressing these two coded themes.

Table 30

Focus Group Responses–Implementing a Common STEM Understanding

Coded Theme	Supporting Quote
Pro Standard District STEM Definition	"I agree completely. For me personally, I think having gone from one administrator within the last two years to another administrator, for me the whole definition of STEM changed, and I think a lot of that had to do with leadership perspective. Prior to the new administration coming, I felt like STEM meant incorporating our theme of agriculture. I believed the problem-based learning activity had to be a certain way with certain criteria and then it seemed like with the new principal coming on board, the problem-based learning took a completely different definition that certain criteria need to be there, but it can be very simple."
	"If everybody had the same idea of what was going on it would be easier to transition across the board. Like if you left here and went somewhere else, then you would know kind of what to expect. The expectations would be the same, and I think that is important for kids to transition from like kindergarten to first grade to second grade all over, wherever, and I think that is important for us too. So that if I'm talking to another teacher, we both have the same understanding of what we are doing and what is expected."
	"When I first started here, STEM had already been I guess technically rolled out in the school, and I had no starting point. I had so many questions, and there was nothing that was like, okay, this is what STEM looks like for this school or in this district. I just had to go off of what I thought I should do."
Against Standard District STEM Definition, but Support for General Definition	"I think there can be a general definition, but I would not want to get to just a district set definition because schools are so focused on different areas of it. For example, one school is in agriculture. Moreover, one is a school of STEAM. Moreover, one school is just STEM. I think to let those schools have their own spin on it based on their clientele, and what they need for the school. However, like I said maybe have a general definition. But not one that schools must stay focused too."
	"You can give us a basic general definition, but the way we do it here would probably freak out some people at other schools because they are not ready and they do not have a full buy-in. So, the way we perceive that is just a step, you know, for different people, but for a general definition, I think that is okay, but I do not think everyone should have the same way of doing STEM activities at their school. It depends on their group."
	"I think that you would have to probably have more of an outline and lay out a process rather than define. Like these are the steps that need to be in place, you know, this is a good starting point, things that may come next, possible next steps and the process."
	"You have to say, "All right, these are some basic expectations, but there's a process to get here."

Table 30 provides some specific quotes supporting each of the identified themes

connecting a common STEM understanding across district STEM schools. These comments provide evidence that some educators are adamant that there should be a common developed STEM understanding across the district for the reason that STEM understanding would be developed and refined. Specifically, one participant described educators' lack an understanding of what STEM consists of and this lack of understanding can impact how others view STEM.

> Sometimes there is confusion, for example, the T in STEM. There is confusion of what counts as technology in STEM, because, really, as far as STEM is concerned, a pencil counts as technology, when you are talking about STEM. However, on a classroom walkthrough, a pencil does not count as technology. It needs to be; I think it should be clarified district-wide so that even administration can understand, when you are walking into a classroom, that if they are looking for a STEM activity, then yes, there, a teacher is using technology or maybe not. A student can use a pencil to help construct an idea or an engineering plan or something. They are still using technology, because it did not exist from nature. It was crafted by humans. So, it still counts. However, without that clarification and common understanding, it is hard to for everyone to be on same page with what STEM means. (Teacher focus group participant, personal communication, November 30, 2018)

However, some educators do not support a standard district STEM definition, though they acknowledged a general definition would suffice, as long as the school made STEM definition personal to the school.

In addition to participants considering whether a district should provide a standard

STEM definition, participants also examined whether elementary schools should implement the STEM innovation. Table 31 displays a quantitative breakdown of each focus group session for this focus group question.

Table 31

Quantitative Breakdown Focus Group Responses–Elementary STEM Implementation

Coded Theme	Referenced by Teachers	Referenced by Leadership	Total
Students are Naturally Curious	5	0	5
Finding Strengths	4	0	4
Students Learn to Persevere	7	0	7
Risk Takers	2	0	2
Start Critical Thinking Earlier	2	1	3
Setting a Foundation for Learning	1	1	2
Other	6 (Building Teamwork Skills, Students are Responsible for own Learning, Encourages Students to Become Flexible Learners, Students Learn from New Experiences)	1 (Prepares Students for Future)	7

Table 31 shows a quantitative breakdown of focus group responses focusing on why elementary schools should implement STEM innovation. In analyzing focus group data, seven themes emerged. These common themes were students are naturally curious, finding strengths, students learn to persevere, risk takers, start critical thinking earlier, setting a foundation for learning, and other. Table 32 displays some specific quotes from each focus group session addressing these coded themes.

Table 32

Focus Group Responses–Elementary Implementation of STEM Innovation

Coded Theme	Supporting Quote
Students are Naturally Curious	"I think the reasons that there are more middle schools and high schools implementing is because there is more of a basis of prior knowledge, so they have more of an ability to problem solve and to engineer because they have more personal experiences with things out in the world. However, I think elementary should implement because all children come to school naturally curious and if you are using problem-based learning and you are using STEM, then we are naturally encouraging that curiosity within students."
Finding Strengths	"I think it gives them an opportunity to take responsibility for their learning. I can tell you something or teach you something but just because I am teaching it one way does not mean that you are going to get it in your brain. However, STEM gives them an opportunity actually to manipulate things and try. I think many kids now come to school and they do not want to know how. Number one, they do not know how to problem solve. Number two, they do not know how to partner up and work together, and number three, our society is very fast paced. We like fast food, we like getting what we want any certain way and so if they try something one time and they do not get it, they give up. So, STEM is giving them an opportunity to say, "Okay, so what, it did not work out this way, what else could you do to make it work?"
Students Learn to Persevere	"Well, I think that they realize too that failure is not final. It might be a little bit of a setback, but you cannot be successful the first time. You can learn from that whole process and understand, "All right, I have got a little bit of setback here. What am I going to do about it?" Moreover, to me that is just a general life-coping skill. I think that they have better-coping skills from just, understanding…"
Risk Takers	"I know I have students who are very much perfectionists, so they do not want to be wrong, they want to get it right, so this teaches them that it is okay to make mistakes and to revise and long as you keep working towards solving the problem."
Start Critical Thinking Earlier	"STEM requires them to learn how to think and honestly when they are younger, they are wired to be more inquisitive. Moreover, sometimes we accidentally take that out of them without meaning to. So, we need to kind of switch it and push them, keep being more inquisitive, keep asking those questions, keep honing that skill a little bit more to be a higher critical thinker."
Setting a Foundation for Learning	"I think at the elementary level we are setting the foundation for what our students will be in the future and I think the earlier we start them, the more prepared they are for their future endeavors using STEM and the more excited they are using those processes."
Other	"It is thinking of down the line. That these students, as they get older, and as they hopefully move onto college and career ready. STEM is one of the fields that is essential right now, and the skills that these students will develop as STEM learners will be what they will need in the workforce, so that was one of the reasons why I wanted to implement because looking down the line. These are the careers that are going to be available and needed. So, getting students started early on this path and interested and excited about it to me was beneficial."

Table 32 provides some specific quotes supporting each of the identified themes

connecting why elementary schools should implement STEM innovation. These comments provide evidence that some elementary educators support implementing the innovation, providing every response was student focused. Specifically, one teacher respondent reflected on how students have grown throughout their elementary years using STEM innovation,

> The kindergarteners are now fourth graders, and they are a little bit more open to retrying, going through that process, having an understanding of it. Whereas in the beginning, if we did not do this and they just went right into [STEM] middle school, they would have to start that foundation and those building blocks in order to get them to be open enough to make that change. (Teacher focus group participant, personal communication, December 6, 2018)

Extent STEM instructional practices are being implemented. Research Question 2, “To what extent are STEM instructional practices being implemented,” was shaped to address perspectives of implementing STEM-based instructional practices. Through this research question, the researcher acquired an understanding of STEM instructional practices utilized at each of the three researched schools. To achieve this understanding, the researcher collected quantitative data from a teacher and leadership survey as well as qualitative data from teacher and leadership focus groups.

This question’s importance in the study finds its roots in the application of STEM instructional practices. As previously identified, STEM education requires educators to change their traditional instructional practices to one that supports an interdisciplinary active learning approach (Freeman et al., 2014); however, when faced with the requirements of STEM education, many educators are nervous to step away from their

traditional instructional approaches (Blowers, 2017). Nonetheless, if educators are to teach STEM education, they must develop instructional practices that encourage creative thinkers (Jacobs, 2010). Kwek (2011) pointed out instructional practices need to require educators to spend “less time explaining through instruction and investing more time in experimental and error-tolerant modes of engagement” (p. 3). The STEM innovation stresses this innovated active learning design, encouraging interest and critical thinking in solving real-world problems relevant to the life of the student (Roland, 2017).

Survey data. Both teacher and leadership surveys included questioning centering around implementation of STEM research-based instructional practices; however, questioning among the two educator surveys differed based on the job title of the respondent. Table 33 displays the alignment between the surveys and Research Question 2.

Table 33

Educator Survey Alignment to Research Question 2

Research Question 2 Component	Aligned Items in Teacher Survey	Aligned Items in Leadership Survey
Discussions and Collaboration Involving STEM Education	7-9 (Likert Scale)	7-8 (Likert Scale)
The extent which STEM has been Implemented	10-11 (Likert Scale)	9-10 (Likert Scale)
Inquiry-Based Learning	12-13 (Dichotomous Response) 14-15 (Likert Scale)	11-12 (Dichotomous Response) 13-14 (Likert Scale)
Engineering Design Process	16-17 (Dichotomous Response) 18-19 (Likert Scale)	15-16 (Dichotomous Response) 17-18 (Likert Scale)
Active Learning	20-21 (Likert Scale)	19-20 (Likert Scale)
Next Generation Science Standards	22 (Likert Scale)	21 (Likert Scale)

Table 33 displays aligned questions found on both the teacher and leadership

surveys. Likert scale questions were used to allow respondents an option in supporting their personal opinions involving STEM education and instructional practices supporting the innovation. Also, dichotomous response questions were used to gain opinions involving if they or others were introduced to specific STEM-based instructional practices.

Discussions and collaboration involving STEM education. To address Research Question 2, three teacher survey questions and two leadership survey questions focusing on STEM instructional practices were developed and examined. Figure 11 shows the responses for these items.

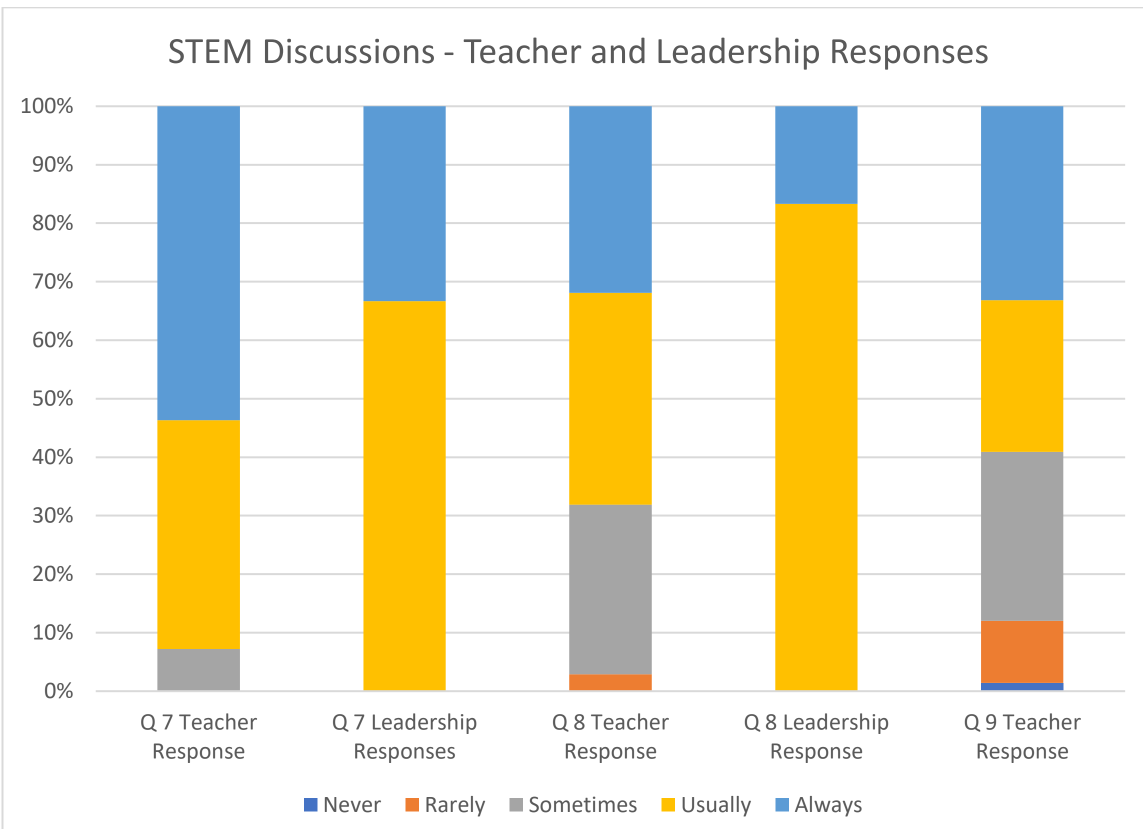


Figure 11. Teacher and Leadership Responses for STEM Discussions and Collaboration. This figure shows the percent of responses the teacher and leadership survey items involving STEM discussions.

As shown in Figure 11, teacher and leadership perspectives differed in how often STEM is discussed. More than half of the leadership respondents (66.7%) responded they usually discuss STEM education with teachers (Q 7 leadership response); however, 53.6% of teacher participants responded leadership team members always discuss STEM education with teachers (Q 7 teacher response), though less than 10% of teacher respondents responded leadership team members only sometimes discuss STEM education with teachers. In addition to frequency data, mode was also utilized to measure central tendency, which is most appropriate for Likert data. The mode for leadership survey question seven is *usually*. Likewise, the mode for teacher survey question seven is also *always*. Also, data analysis revealed teachers differed on how often other teachers discuss STEM education with one another each month (Q 8 teacher response). Some teachers responded teachers always discuss STEM education with one another, though 2.9% of respondents replied other teachers rarely discussed STEM education with them. The mode for teacher survey question eight is *usually*. Also, in leadership survey question eight, respondents examined how often teachers discuss STEM education with a member of the school's leadership team. Analyzed data revealed 83.3% of leaders responded teachers usually discuss STEM education with leadership members. Similarly, mode for leadership survey question eight is *usually*. Also, in question nine of the teacher survey, teachers examined how often they collaborate with other teachers on STEM education. Analyzed data revealed teachers greatly differed in the perceptions of how often they collaborate with other teachers on STEM education. While some teachers (33.3%) responded they always collaborate with teachers on STEM education, 1.4% of teachers replied they never collaborate with teachers on STEM education.

The extent to which STEM has been implemented. In addition to educators examining discussions and collaboration involving STEM education, teachers and leaders examined the extent to which STEM has been implemented. To address Research Question 2, two teacher survey questions and two leadership survey questions focusing on the extent to which STEM has been implemented were developed and examined. Figure 12 shows the responses for these items.

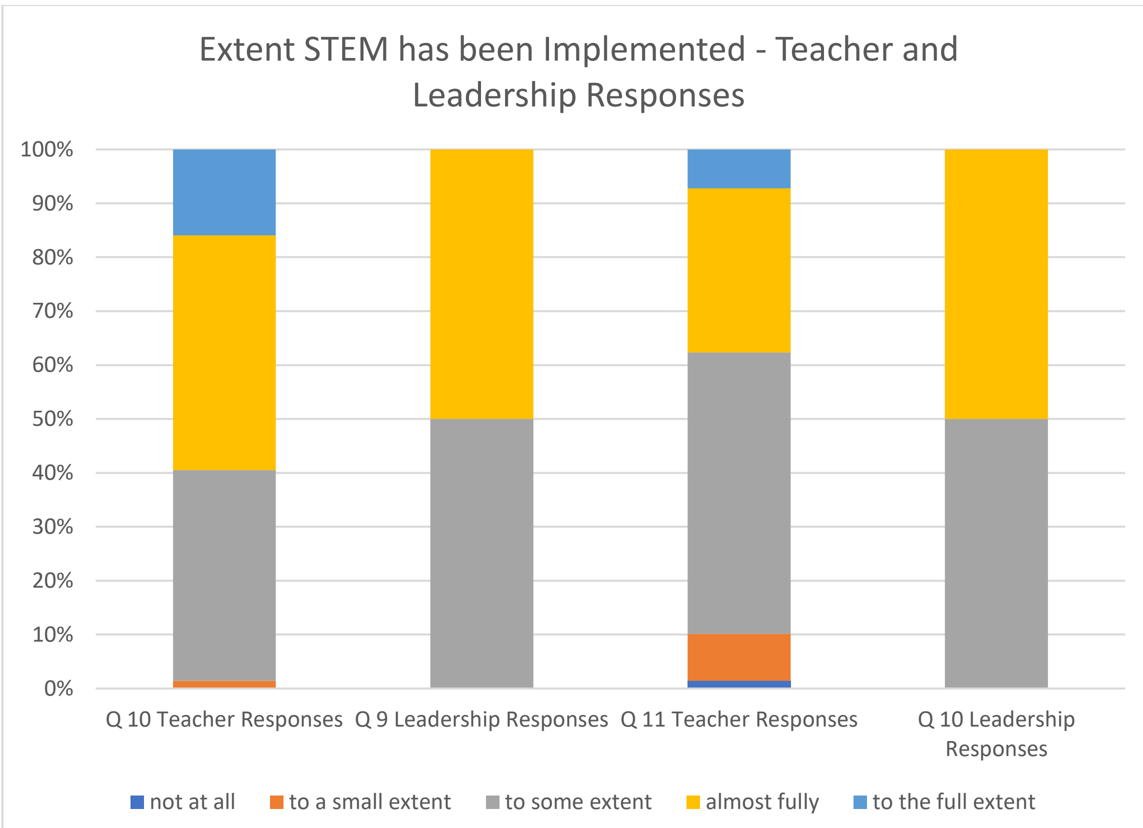


Figure 12. Teacher and Leadership Responses for Extent STEM has been Implemented. This figure shows the percent of responses the teacher and leadership survey items involving extent STEM has been implemented.

Figure 12 displays analyzed data involving teachers and leadership opinions entailing to what extent educators believe STEM has been implemented. Specifically, question 10 of the teacher survey and question nine of the leadership survey examined to

what extent respondents believed STEM has been implemented. Quantitative analyzed data revealed several (15.9%) teachers responded the school had implemented STEM to the full extent. Leaders did not agree; no leadership respondents replied they believed their school had implemented STEM to the full extent, though 43.5% of teachers responded they believed the school had implemented STEM almost fully. This is slightly comparable to leadership respondents who 50% replied they believed the school had implemented STEM almost fully. Also, mode for question 10 of the teacher survey is *almost fully*. While mode for question nine of the leadership survey is *to some extent*. Though, multiple modes existed for leadership survey question nine, the smallest value is shown. Also, analyzed data revealed discrepancies between teachers and leaders when examining teacher perspectives concerning to what extent they believe they have implemented STEM in the classroom (Q 11 teachers) and leadership perspectives concerning to what extent they have observed STEM being used in classrooms (Q 10 leadership). Analyzed data revealed 50% of leadership respondents responded they have observed STEM being used *to some extent*. Likewise, 50% of leadership respondents responded they have observed STEM being used *almost fully*. Mode for question 10 of the leadership survey is *to some extent*; however, 52.2% of teacher respondents believe they have implemented STEM *to some extent,* though 8.7% of respondents responded they have only implemented STEM *to a small extent*. Likewise, 7.2% of teacher respondents replied they have implemented STEM *to the full extent*. Mode, for question 11 of the teacher survey is *to some extent*.

Use of STEM-based instructional practices. In addition to educators examining the extent to which STEM has been implemented, Research Question 2 also examined

teachers' and leaders' use of inquiry-based learning, EDP, active learning, and Next Generation Science Standards. Specifically, teacher survey questions 12 and 13 examined inquiry-based learning. Likewise, leadership survey questions 11 and 12 also examined this instructional practice. Figure 13 shows teacher and leadership responses for inquiry-based learning.

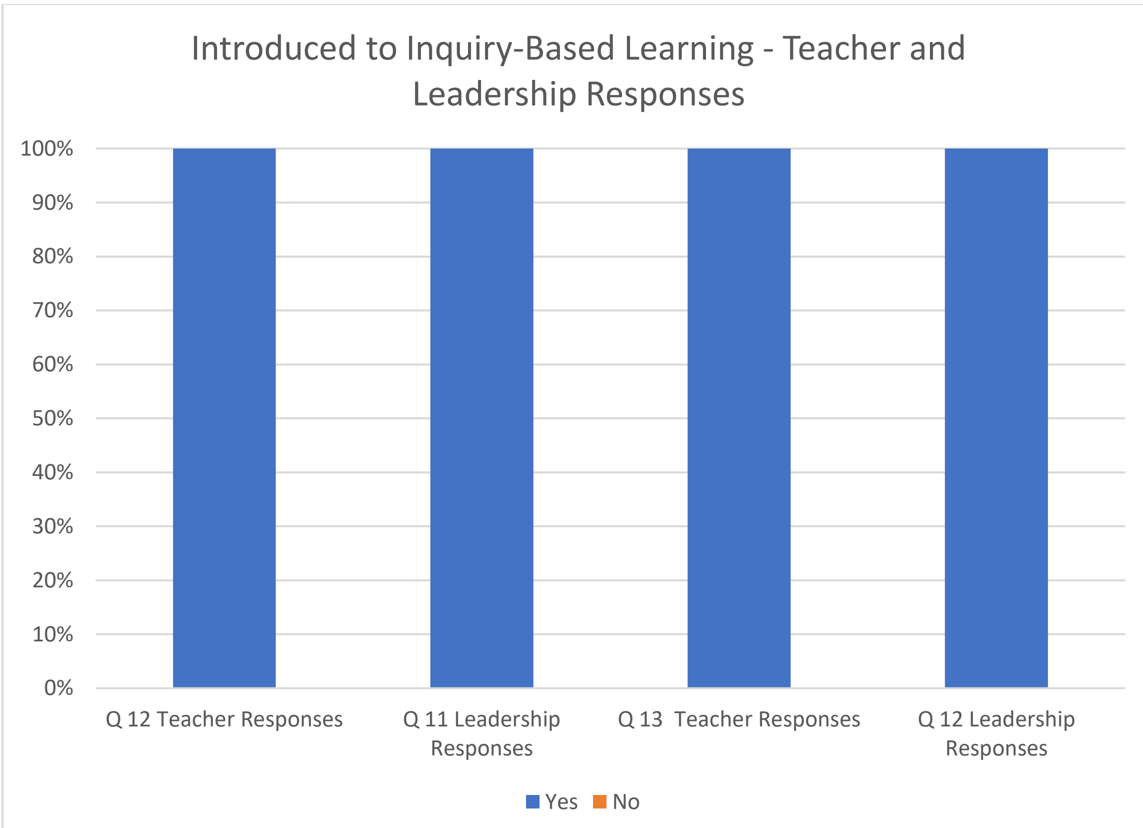


Figure 13. Teacher and Leadership Responses for Introduction to Inquiry-Based Learning. This figure shows the percent of responses for questions 12 and 13 of the teacher survey and questions 11 and 12 of the leadership survey. Both surveys are compatible for these two questions.

As shown in Figure 13, both teacher and leadership respondents agreed both members of the school's staff and themselves have been introduced to inquiry-based learning.

In addition to these two inquiry-based instructional practice questions, two

additional questions examined teacher and leadership involvement with inquiry-based practices. Specifically, teacher survey items 14 and 15 examined how often the school encourages educators to use inquiry-based learning and how often the teacher uses inquiry-based learning in the classroom. Figure 14 shows teacher responses for these items.

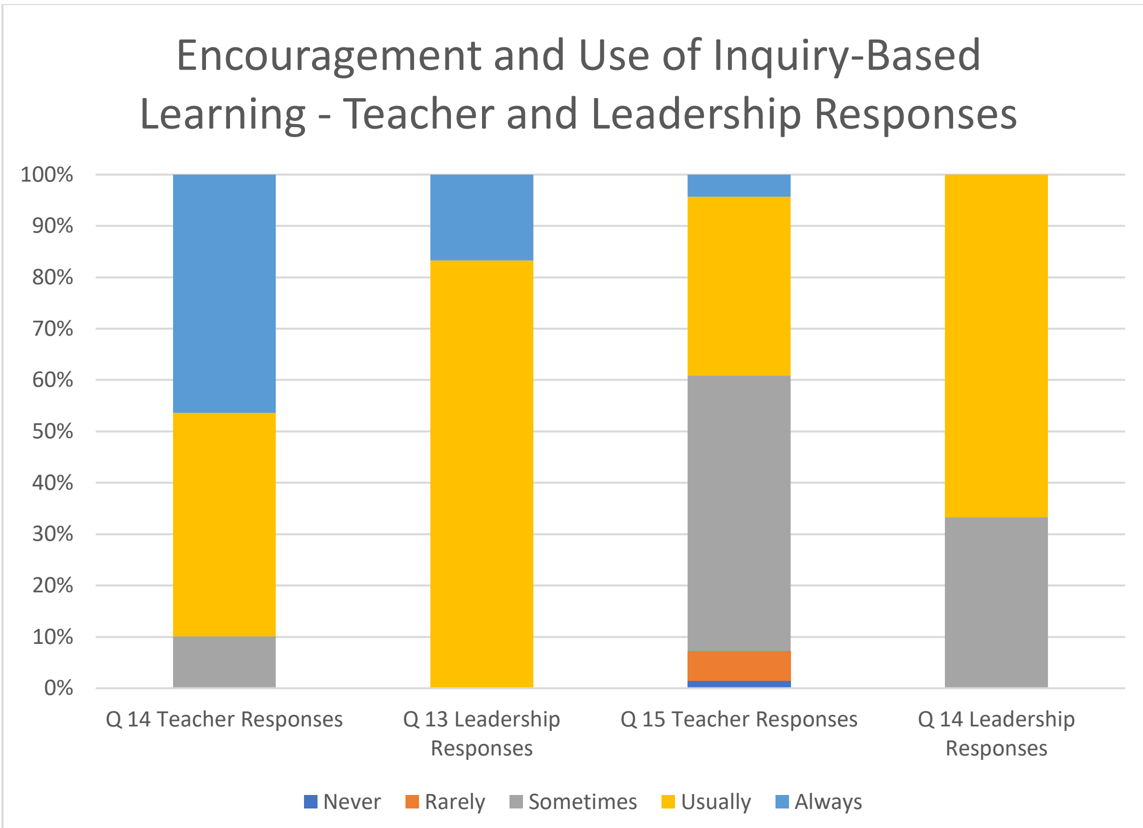


Figure 14. Teacher and Leadership Responses for Encouragement and Use of Inquiry-Based Learning. This figure shows the percent of responses for teacher and leadership survey items involving encouragement and use of inquiry-based learning instructional practices.

As shown in Figure 14, 83.3% of leadership respondents responded the school's leadership team *usually* encourages the use of inquiry-based learning (Q 13 leadership survey); however, only 43.5% of teacher respondents agreed with leaderships' pronouncement. Also, 46.4% of teacher respondents responded the school *always*

encourages this practice (Q 14 teacher survey). Also, 10.1% of teacher respondents responded the school only *sometimes* encourages inquiry-based learning practices. Mode for question 14 of the teacher survey is *always.* Mode for question 13 of the leadership survey is *usually*. Also, analyzed data revealed 53.6% of teachers responded they use inquiry-based learning in the classroom *sometimes* (Q 15 teacher survey); however, 66.7% of leadership respondents responded they *usually* observe inquiry-based learning in classrooms. Mode for question 15 of the teacher survey is *sometimes*. While mode for question 14 of the leadership survey is *usually*. This discrepancy could result from a lack of understanding of inquiry-based learning.

In addition to educators examining the use of inquiry-based learning, Research Question 2 also examined teacher and leadership use of EDP; specifically, teacher survey questions 16-19 and leadership survey questions 15-18. However, the first two questions focused on introduction to EDP. Figure 15 displays teacher and leadership responses for these two items.

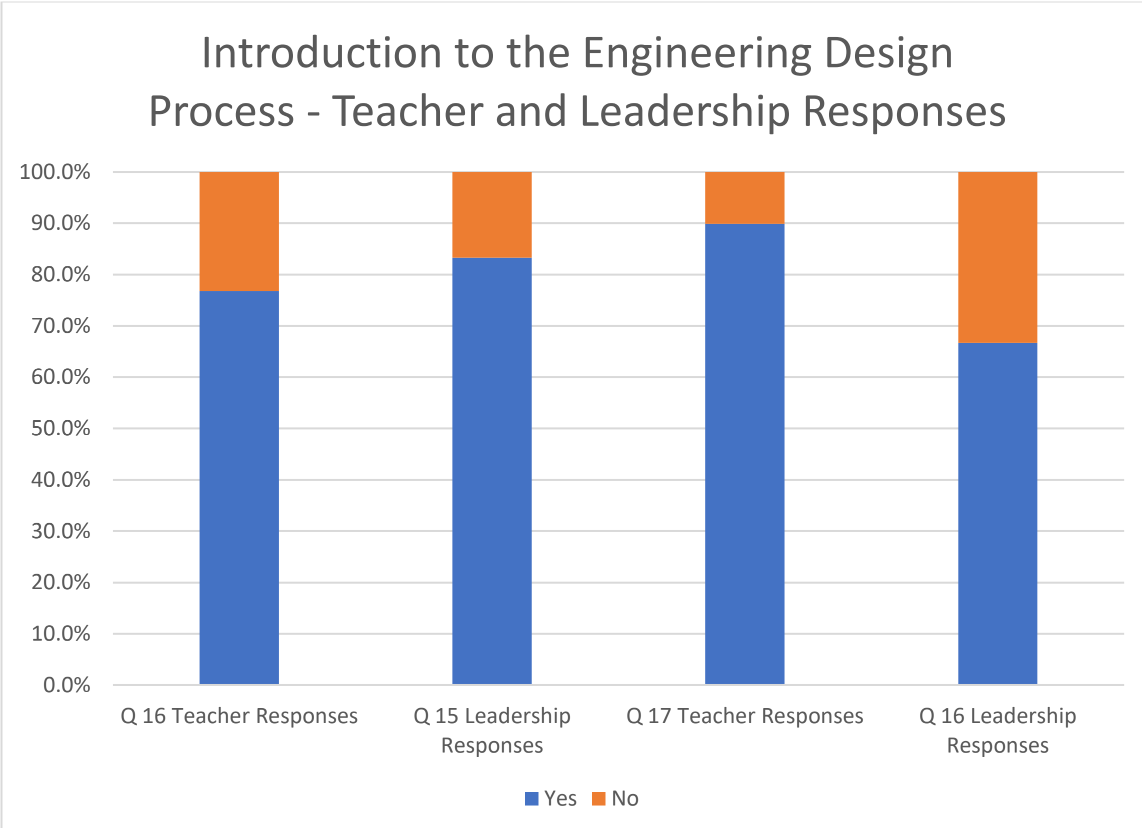


Figure 15. Teacher and Leadership Responses for Introduction to EDP. This figure shows the percent of responses for questions 16 and 17 of the teacher survey and question 15 and 16 of the leadership survey.

As shown in Figure 15, teacher survey item 16 and leadership survey item 15, which focused on respondents examining if they have been introduced to EDP, analyzed data revealed 23.2% of teachers replied they have not been introduced to EDP, while 76.8% of teachers responded they have been introduced to EDP. Mode supported the analyzed data, which revealed mode is yes for both teachers and leadership for this item. Also, analyzed data shows 33.3% of leadership respondents replied staff members have not been introduced to EDP; however, the majority of both teachers and leaders responded other staff members have been introduced to EDP. Mode for this item is also yes.

In addition to these EDP questions, two additional questions focused on EDP were examined. Figure 16 shows responses for survey items involving EDP.

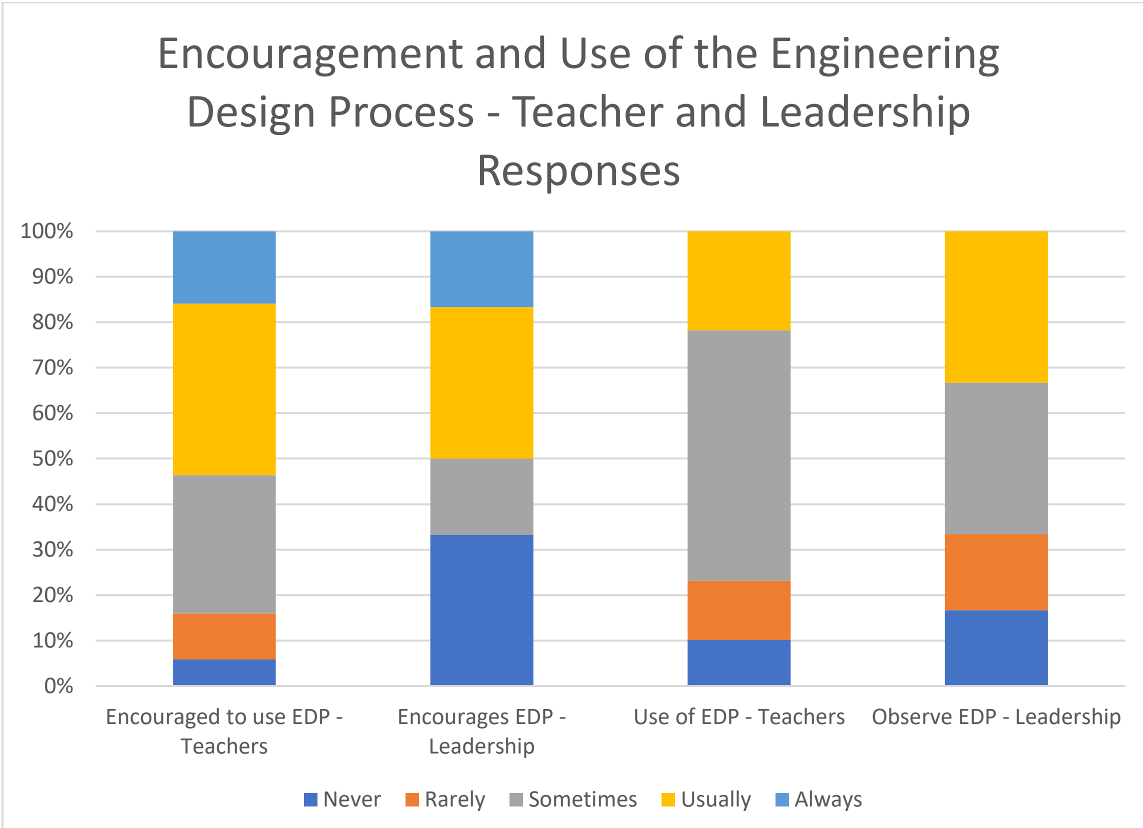


Figure 16. Teacher and Leadership Responses for Encouragement and Use of EDP. This figure shows the percent of responses involving encouragement and use of EDP.

As shown in Figure 16, teacher survey item 18, which focused on respondents examining how often the school encourages educators to use EDP, data revealed differences among teacher and leadership perspectives. Some teachers (5.8%) responded they are *never* encouraged to use EDP practices. Also, 10.1% of teachers responded they *rarely* and 30.4% responded they *sometimes* are encouraged to use EDP practice, though 33.3% of leadership respondents responded they *never* encourage use of the process. Mode for encouraged to use EDP, according to the teacher survey, is *usually*; however, mode for encourages EDP, according to the leadership survey, is *never*. Though two

modes exist, the smallest value is shown. Also, the use of EDP and observe EDP can be viewed. Analyzed data analysis revealed 55.1% of teacher respondents responded they *sometimes* use EDP, while 33.3% of leadership respondents responded they *usually* observe EDP in classrooms and 33.3% of leadership respondents responded they *sometimes* observe EDP practices. Mode for use of EDP, according to the teacher survey, is *sometimes*. Also, mode for observe of EDP, according to the leadership survey, is *sometimes*. Though two modes exist, the smallest value is shown.

In addition to educators examining the use of EDP, Research Question 2 also examined teacher and leadership use of active learning activities; specifically, teacher survey questions 20 and 21 and leadership survey questions 19 and 20. Figure 17 displays teacher responses for these two items.

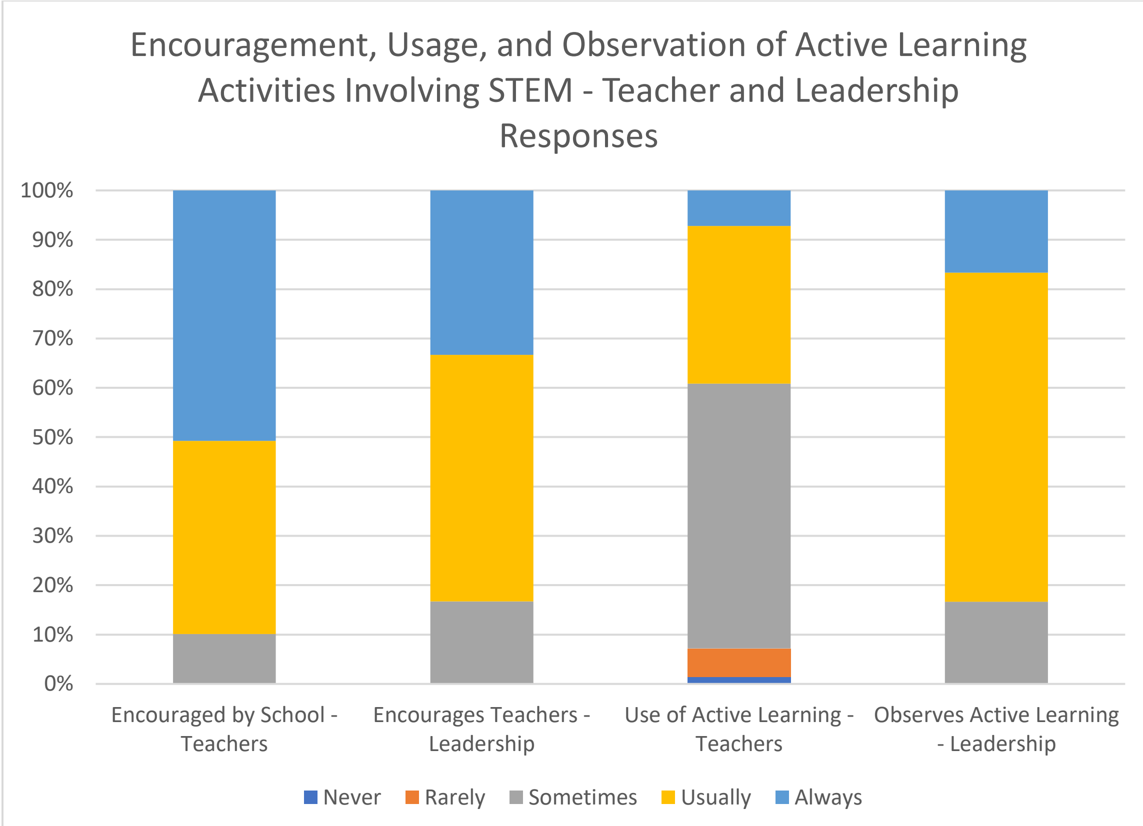


Figure 17. Teacher and Leadership Responses for Encouragement and Use of Active Learning. This figure shows the percent of responses encouragement and use of active learning.

As shown in Figure 17, analyzed survey data of both teachers and leaders are slightly similar with regards to encouragement given in the use of active learning, though 50.7% of teachers responded they *always* are encouraged by school leaders to use active learning activities involving STEM, which is supported by mode, which revealed mode is *always*. However, 50% of school leaders responded they *usually* encourage teachers to use active learning activities, which is also supported by mode; mode is *usually* for this leadership item. Analyzed data also revealed discrepancies between teacher perspectives, involving use of active learning activities in the classroom, and leadership perspectives, involving the observation of active learning activities to solve real-world problems.

Fifty-three point six percent of teachers responded they *sometimes* use active learning activities in the classroom. A few (7.2%) teachers even responded they never or rarely use the STEM-based activities; however, 66.7% of leadership respondents responded they usually observe active learning activities in the classroom. This discrepancy can be related to a lack of understanding of active learning. Mode for use of active learning, according to the teacher survey, is *sometimes*. Also, mode for observes active learning, according to the leadership survey, is *usually*.

In addition to educators examining the use of active learning activities, Research Question 2 also examined teacher and leadership encouragement of Next Generation Science Standards. Specifically, teacher survey question 22 and leadership survey question 21. Figure 18 displays teacher responses for these two items.

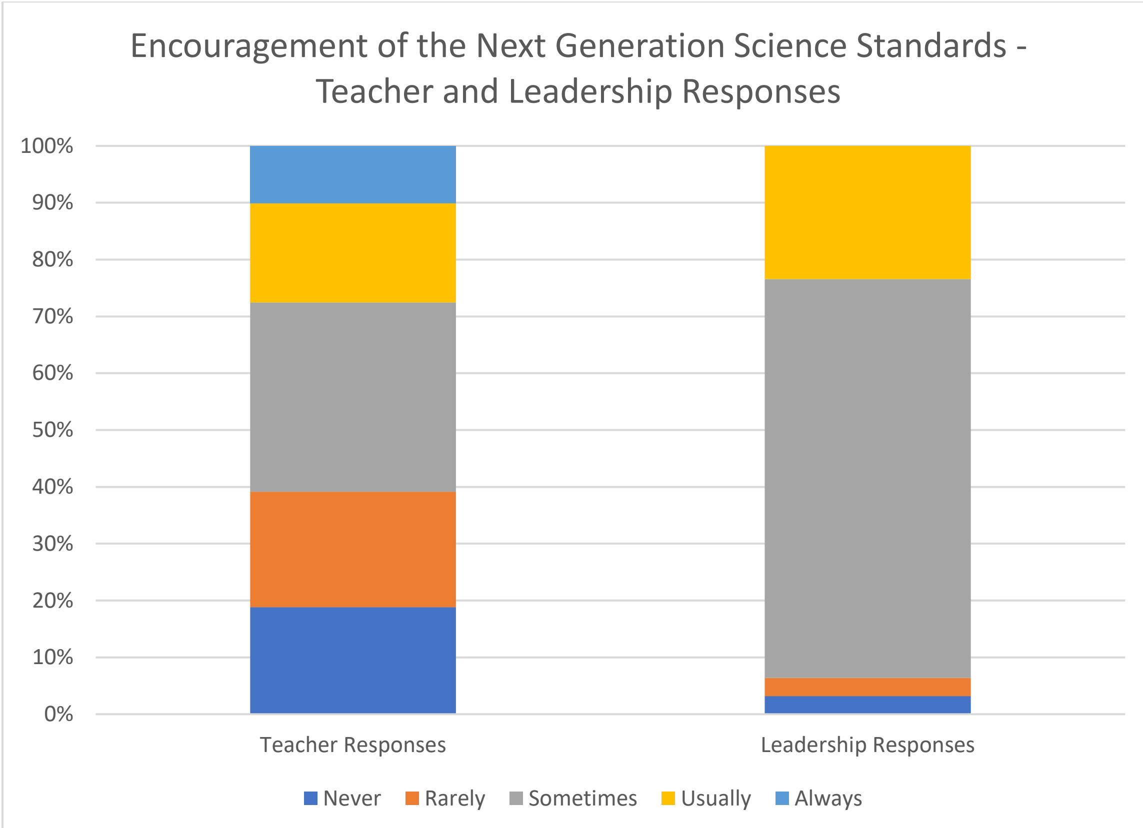


Figure 18. Teacher and Leadership Responses for Next Generation Science Standards. This figure shows the percent of responses for both teachers and school leaders for items number 22 of the teacher survey and item number 21 of the school leader survey.

As shown in Figure 18, teachers and leaders varied greatly in perspectives involving encouragement in use of Next Generation Science Standards. While 50% of leadership respondents responded they *sometimes* encourage the use of the standards, teachers varied in their responses. This difference may be due to a lack of understanding of the standards. Also, mode was used for this teacher survey, which revealed mode is *sometimes*. Also, mode was used for the leadership survey, which determined leaders *sometimes* encourage the use of Next Generation Science Standards.

Focus group data. Focus group sessions were conducted at each of the three elementary schools to gain an understanding of the opinions and perspectives of

elementary educators; therefore, three teacher focus group sessions and one leadership focus group session were conducted to gain multiple perspectives. All four focus group sessions encouraged participants to reflect upon two questions involving instructional practices. These two questions provided an understanding of educator perspectives addressing Research Question 2. This question, "To what extent are STEM instructional practices being implemented," enabled the researcher to gain an understanding of how educators prepared to change traditional practices of teaching to practices that support STEM education; however, the two questions used to examine this perspective differed based on the job title of those participating. Therefore, two different questions were used for teachers and two different questions were used for leadership participants.

The first focus group item supporting this research question was rooted in the understanding that STEM education requires educators to change from traditional teaching practices to practices that support integrated active learning; therefore, the question was shaped to examine perspectives of both teachers and leaders. Teachers were asked to describe how they changed their instructional practices to practices that support STEM education. Likewise, leaders were asked to describe how the leadership team prepared teachers to change their traditional practices to practices that support STEM education. Table 34 displays a quantitative breakdown of the teacher focus group sessions, and Table 36 displays a quantitative breakdown of the leadership focus group session.

Table 34

Quantitative Breakdown Teacher Focus Group Responses–Preparing to Change

Coded Theme	Referenced by Teachers
Letting Go	4
Trial and Error	3
Learn how to Facilitate	5
Book Study	2
Professional Development	5
Co-teaching	4
Grants	3
Research	3
Changing Mindset	3
Partnerships	2
Visiting STEM Schools	1

Table 34 reveals a quantitative breakdown of the teacher focus group item focusing on preparing to change instructional practices. In analyzing the focus group data, 11 themes emerged focusing on how teachers prepared to change from traditional practices to practices that supported STEM education. Quantitative breakdown revealed the top practices teachers utilized to change instructional practices were letting go, learning how to facilitate, professional development, and co-teaching. Some specific quotes supporting these top supports are explored in Table 35.

Table 35

Teacher Focus Group Responses–Preparing to Change Practices

Coded Theme	Supporting Quote
Letting Go	"I am still learning. I feel like I barely know anything when it comes to STEM, but I have had to let go and step back and not tell students what they could do. I have had to learn to have students tell me what they are going to do with what they have."
	"Be willing to let go."
	"Accept mess and accept loudness, that is the hardest part. "Accept disarray."
Learn how to Facilitate	"As a teacher you want to help them, but really you are helping them by not stepping in, not giving them the answer. I think it is constantly evolving the more we learn."
	"Learn not to talk all the time. Be willing to let students be the talkers. Let students figure it out."
	"Do not answer questions. Ask questions. For me, it is standing back and saying, "Alright, I cannot answer that question. You know what you have tried already, what else could you try? Some students do not like that."
	"I had to learn how to be a facilitator and ask questions. Today, I answer very few questions when we are completing a STEM activity."
Professional Development	"I think that our trainings are going to have to change as well in order for us to change our instructional practices. I think a lot of times that the trainings that we go to are more geared towards upper grades, not even towards upper elementary."
	"We had training with [STEM professional development center] where they came and kind of trained us on different qualities and things, we need to be thinking about for lesson planning for our problem-based learning."
	"I worked with [STEM professional development center] over the summer and attended an amazing workshop that helped, she would model [STEM] and she would facilitate like we were the kids, it was amazing to watch how you thought she was going to go down this path and the lessons turned out to be completely different. I was all about how she facilitated, how she presented, and then how we, as the students, had to get there."
Co-teaching	"We had a partner in crime in a sense, so that helped."
	"We have been collaborating with other grade levels. So that is helpful to pair up. Collectively working with another teacher helps bring you out of your comfort zone."

Table 35 displays some specific quotes regarding the identified themes of letting go, learn how to facilitate, professional development, and co-teaching. While professional development would seem to provide valuable insight into teachers' understanding of STEM instructional practices, these sessions were not always viewed as

helpful by teachers. Teachers learning how to let go and exploring how to facilitate provided more insight into how to adapt teaching practices than most professional development experiences.

As mentioned previously, leaders were also asked to examine how the leadership team prepared teachers to change their traditional practices to practices that support STEM education. Table 36 displays a quantitative breakdown of the leadership focus group session.

Table 36

Quantitative Breakdown Leadership Focus Group Responses–Preparing for Change

Coded Theme	Referenced by Leadership
Freedom	2
Professional Development	2
Visiting STEM Schools	1
Understand School STEM Design	2
Build STEM Vocabulary	2
Other	2 (Teacher Buy-In, Encouragement to Keep Trying)

Table 36 reveals a quantitative breakdown of the leadership focus group session examining how the leadership team prepared teachers to change their traditional instructional practices. In analyzing the focus group data, six themes emerged. Some specific quotes supporting these supports are explored in Table 37.

Table 37

Leadership Focus Group Responses–Preparing for Change

Coded Theme	Supporting Quote
Freedom	"Give them the freedom to take a risk." "Allowing people to explore and try different things and without fear. I think that gave them some comfort level. They were able to just relax a little bit, implement some things that they may have never done before. Moreover, they saw some of the benefits, and they just kept going with it. Moreover, encouraging them to keep trying and doing these STEM activities."
Professional Development	"We started with a small group to be on a team to research and start piloting some parts of it. We had training we went to. We partnered with [a STEM professional development education center]. We took a team and learned about problem-based learning. It was their job to implement, and then share with teachers about what went well. Some of their challenges."
Visiting STEM Schools	"It is good to take things from other schools. Moreover, then kind of figure out how it is going to work in your setting with your population." "It is good to work together with other schools and with the visits we have done."
Understand STEM School Design	"Teachers have been doing STEM things. They just did not know. Helping people understand that makes [them realize] they can do that."
Build STEM Vocabulary	"Find a common language to identify things and classify."
Other	"Give [teachers] the freedom to take a risk. Moreover, at our school, it was teacher-led from the beginning. So once the teacher started it there, it got some momentum with it. Moreover, then all the teachers were like "yeah, we are in." So, it was buy-in from the beginning." "I think just supporting them and letting them know if you have questions let us know. Here are some thoughts and ideas if we could have somebody else share… moreover, collaborating that is certainly a big help to clarify that it is okay to look different."

Table 37 displays some specific quotes regarding the identified themes. Previously, it was discussed in the teacher focus group sessions that teachers learned how to facilitate STEM through learning how to let go. This idea was supported by the leadership focus group session in which participants described giving teachers freedom to take risks and allow for exploration. Each of the above identified themes encouraged educators to change their traditional practices to practices that support STEM.

The second focus group item supporting Research Question 2 was rooted in the foundation of the research question, "To what extent are STEM instructional practices being implemented." Therefore, the question was shaped to examine perspectives of both teachers and leaders. Teachers were asked to examine how they are implementing STEM in the classroom. Likewise, leaders were asked to examine how the school is implementing STEM. Table 38 displays a quantitative breakdown of the teacher focus group sessions, and Table 40 displays a quantitative breakdown of the leadership focus group session.

Table 38

Quantitative Breakdown Teacher Focus Group Responses–Implementing STEM

Coded Theme	Referenced by Teachers
Interdisciplinary with Literacy	6
Monthly Home Challenges with Parents	2
EDP (Constructing)	9
Learning Centers	2
Coding	1

Table 38 reveals a quantitative breakdown of the teacher focus group item focusing how teachers are implementing STEM in the classroom. In analyzing the focus group data, five themes emerged. Some specific quotes supporting these supports are explored in Table 39.

Table 39

Teacher Focus Group Responses–Implementing STEM Innovation

Coded Theme	Supporting Quote
Interdisciplinary with Literacy	"For Thanksgiving, they created a big turkey, and there was an edible STEM project. It was tied into book features. They had to complete research and questions and then create their sweet turkey. As we move into our weather unit, they will have to design a gingerbread house before the upcoming holiday season, and we can talk about extreme weather patterns, and we use a hair dryer to see if we can blow down their gingerbread house. Talking about the different weather patterns, extreme storms, fronts, and air pressures, we tie that all in. We have also done clouds, where they are creating a cloud in a bag, and they are displayed in the window. We are constantly applying STEM, it is not just a build and goes, so to speak. They are using it in their math application. The kids love it, the engagement and the collaboration, and they want more. That is what we are looking at is always providing rigor, and it is amazing how well it even runs itself elsewhere, like a Daily Five setting, the children are ready and wanting to take that always a step further." "We learn through literature. For example, we read [children's book] and then kids constructed a house that would hold up against wind, rain, and snow."
Monthly Home Challenges with Parents	"A monthly STEM at home challenge the kids absolutely love taking home. They work on something and bring it back for the due date and then it is showcased in the display cases. The kids are excited and cannot wait for the next month. Some parents come in and they will say, "I do not know who enjoyed this project more, his dad or him."
EDP (Constructing)	"When working on the engineering aspect of STEM, students do the design first, draw it on their piece of paper, and then they take the materials, well they decide on what materials they are going to pick with their partner. Usually, I have my kids work in groups of three, because if it gets any bigger than that they just cannot handle it. We have also done some building with different materials, blocks and popsicle sticks for letters and numbers too because they need to see visually. Like, "Oh, I can build an A with this popsicle stick here, and this popsicle stick there or I can build a triangle, we have done that with shapes."
Learning Centers	"We have small kits where we put them in a learning center, and it may not be a full-blown lesson, it might be little bits and pieces of things where they have a task or something, or there is a job card."
Coding	"We use [a coding program] on the Google Browser. The kids were really excited. Using a real coding language that was used to make the browser that they were coding in. We talked about the other different kind of coding languages that people really use, and we talked about the different steps, how we, programmers go through steps, the algorithm."

Table 39 displays some specific quotes regarding the identified themes. Teachers provided examples of lessons that have incorporated STEM design; however, teachers also mentioned a school STEM directive with monthly at-home STEM challenges

students complete with help from parents. This challenge provides opportunities for parents to become involved in their child's learning and also learn about STEM in the process. Most of the practices mentioned involved students constructing or working towards EDP. While STEM involves more than EDP, these experiences are at the forefront of teachers' experiences when discussing STEM.

As mentioned previously, leaders were also asked to examine how the school is implementing STEM. Table 40 displays a quantitative breakdown of the leadership focus group session.

Table 40

Quantitative Breakdown Leadership Focus Group Responses–Implementing STEM

Coded Theme	Referenced by Leadership
Part of School Plan	2
Other	6 (Addressing Literacy Component, Community Involvement, Requirement of Certain Number of Lessons, Redesigning Skills to Pose in Question Format, Continue Learning Best Practices, Building Inquiry-based Practices to Solve Problems)

Table 40 reveals a quantitative breakdown of the leadership focus group item focusing how the school is implementing STEM. In analyzing the focus group data, two themes emerged. Some specific quotes supporting these supports are explored in Table 41.

Table 41

Leadership Focus Group Responses–Implementing STEM Innovation

Coded Theme	Referenced by Leadership
Part of School Plan	"It is part of the school plan, but it probably does not have to be. I think the teachers have seen the vale and have seen it not just with STEM activities. STEM is spilling over into different subjects and other things that I have seen. Teachers are excited about doing STEM lessons and they want to do them."
Other	"We have one problem-based learning problem a month and one STEM activity a month. So essentially two things a month is the expectation. Problem-based learning is a piece of STEM education. So, the problem-based learning that one part. Then the other STEM piece could be something with engineering, or math, or science, or technology. It could be about careers. It could be about lots of different pieces. One problem-based learning is specific to the partnership that we had, or we have. Then teachers are just finding other pieces that are STEM-based like build day. For example, a kindergarten class today was building a house for the three pigs that could not get blown down. So, classes are including reading pieces into their building. It was not a real-world problem-based learning formal inquiry piece, but it is an inquiry."
	"Using a problem-based mind or a creative mind to problem solve with daily activities. So, presenting things in more of a problem and like, addressing how are we going to solve this problem? Alternatively, what is our solution? Alternatively, even if classes are working on a reading skill, they are posing that skill in a question form. This direction encourages students to think a little bit more through what they are doing."

Table 41 displays some specific quotes regarding the identified themes. School leaders are providing support for teachers in implementing STEM; however, to encourage growth, leaders are including STEM as part of the school plan. In addition, leaders are requiring a certain number of STEM lessons to be completed. Also, leaders are working towards having teachers pose learning targets in question form. All of these elements encourage STEM practices to become a fixture in the school's environment.

Successes and challenges in implementing STEM. Research Question 3, "How do elementary educators characterize successes and challenges in implementing the STEM innovation," was shaped to address the perceptions of successes and challenges in implementing STEM. Through this research question, the researcher acquired an understanding of successes and challenges associated with implementing STEM

innovation. To gain this understanding, the researcher collected quantitative data from a teacher survey and a leadership survey as well as qualitative data from teacher and leadership focus groups.

This question's importance in the study finds its roots in the idea that implementing any innovation will result in successes and challenges along the way. Many organizations utilize Kurt Lewin's model of organizational change (unfreezing, changing, and refreezing) when progressing through the implementation of new innovation. Each of the phases of the model help to develop a shared vision, leading to the success of the intended change (Hussain et al., 2016); however, this vision needs to become shared by everyone involved in order for the innovation to become the norm (Hussain et al., 2016). Hall and Hord (2015) supported this declaration, acknowledging fostering and supporting a collective vision will encourage change in innovation. The success of the STEM innovation depends on this shared vision of support.

Survey data. Both teacher and leadership surveys included questioning centering around successes and challenges associated with STEM implementation; however, questioning among the two educator surveys differed based on the job title of the respondent. Table 42 displays the alignment between the surveys and Research Question 3.

Table 42

Educator Survey Alignment to Research Question 3

Research Question 3 Component	Aligned Items in Teacher Survey	Aligned Items in Leadership Survey
Top Three Supports Needed	29 (Multiple Response)	28 (Multiple Response)
Leadership Team Accomplishments	30 (Multiple Response)	29 (Multiple Response)
Personal STEM Accomplishments	31 (Multiple Response)	30 (Multiple Response)
Successes in Implementing the STEM Innovation	32 (Open-Ended)	31 (Open-Ended)
Possible Leadership Offerings to help make STEM Implementation Successful	33 (Multiple Response)	32 (Multiple Response)
Possible Personal Achievements to help make STEM Implementation Successful	34 (Multiple Response)	not found in leadership survey
Top Three Challenges Elementary Educators Face When Implementing STEM	35 (Multiple Response)	33 (Multiple Response)
Challenges of Implementing the STEM Innovation	36 (Open-Ended)	34 (Open-Ended)

Table 42 displays aligned questions found on both the teacher and leadership surveys. Each question was formed with the understanding that successes and challenges are present when implementing STEM innovation. To support Research Question 3, eight survey questions were developed and analyzed for the teacher survey. Also, seven survey questions were developed and analyzed for the leadership survey. Each question differed in format based on the type of feedback required.

Successes in implementing STEM. To address Research Question 3, four teacher and leadership survey questions focusing on successes were developed and examined. The first question was rooted in characterizing the top three supports elementary educators need to implement STEM successfully. Figure 19 shows teacher and

leadership responses for the first item.

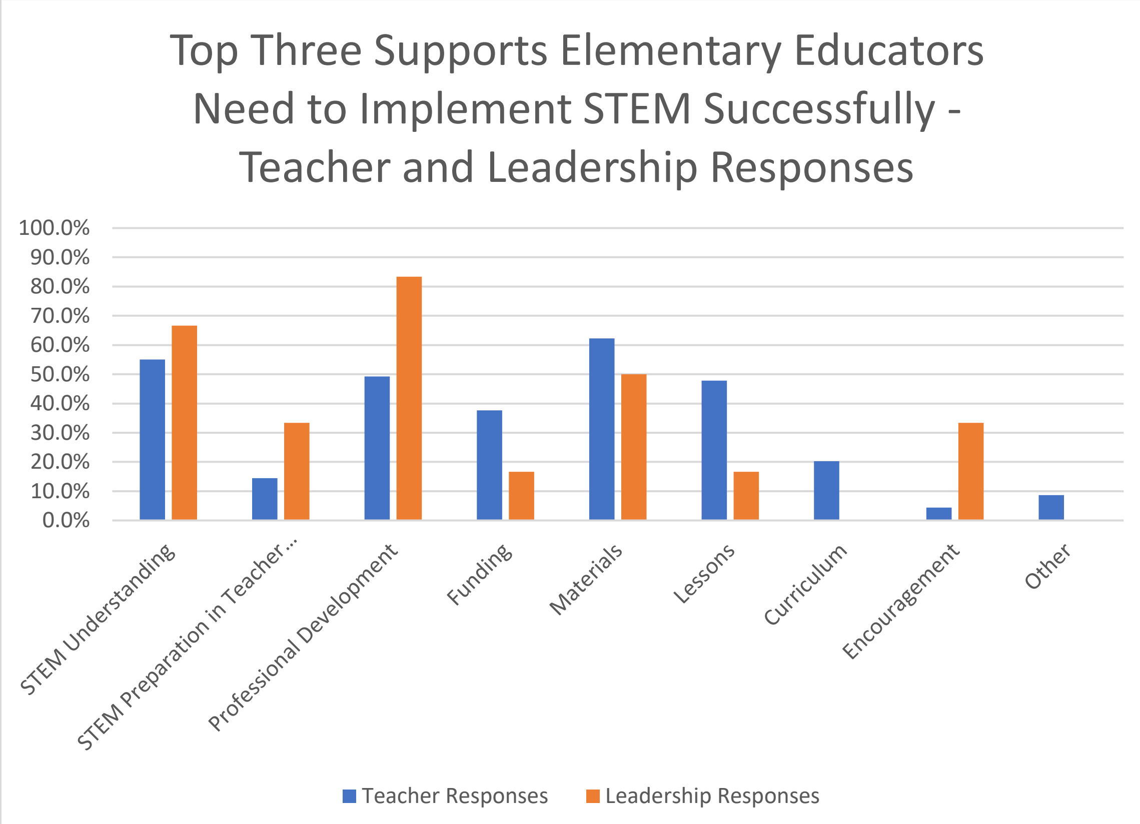


Figure 19. Teacher and Leadership Perspectives on Top Three Supports Needed to Implement STEM. Information found in the figure conveys teacher and leader perspectives on the top three supports elementary educators need to implement STEM successfully.

As shown in Figure 19, teachers and leadership respondents characterized the top three supports elementary educators need to implement STEM successfully. Quantitative data analysis revealed teachers and leaders agreed on the top three characterized supports needed to implement STEM successfully. They perceived the top supports needed were STEM understanding, materials, and professional development.

In addition to educators examining the top three supports needed to implement STEM successfully, teachers and leaders also examined what leadership teams accomplished to help make teacher implementation successful. This second question was

rooted in the understanding that to successfully implement an innovation support from the leadership team, it is necessary for change to be perceived important and for change to be successful. Figure 20 shows teacher and leadership responses for this second item.

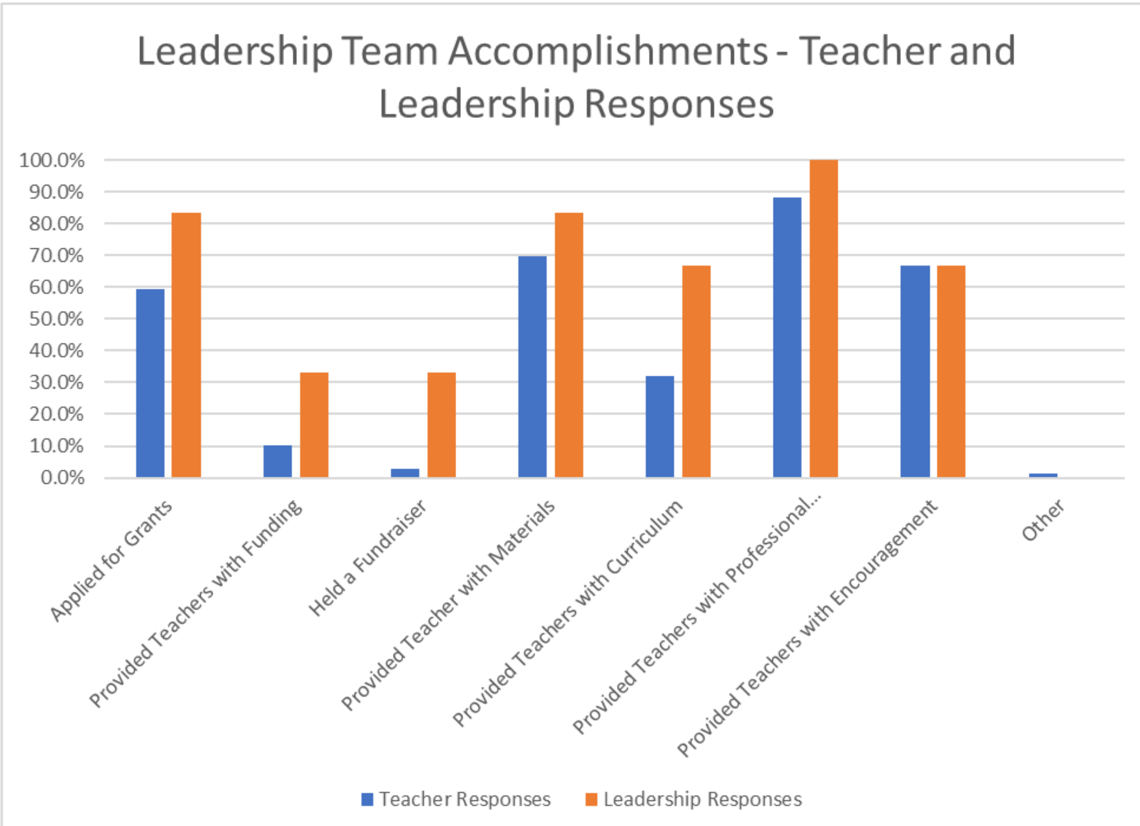


Figure 20. Teacher and Leadership Responses: Leadership Team Accomplishments. Information found in the figure conveys teacher and leadership responses on what their school's leadership team accomplished to help make teacher implementation of the STEM innovation successful.

As shown in Figure 20, teachers and leaders differed in their perceptions of accomplishments the leadership team performed to help make teacher implementation successful, though quantitative data analysis revealed common perceptions did exist. More than half of both teachers and leadership respondents responded leadership teams provided teachers with STEM professional development, materials, and encouragement as well as leaders applied for grants to help support funding of STEM.

Additionally, educators examined what they personally accomplished to help make implementation successful. This third question was rooted in the understanding that every educator can perform tasks to help aid in implementation of an innovation. While the question examined a similar theme, both the teacher and leadership item differed based on the perspective of the individual; therefore, this third question asked teachers to examine what they accomplished to help make their implementation successful and leaders examined what they accomplished to help make teacher implementation successful. However, both questions examined personal accomplishments performed to help make STEM implementation successful. Since, the questions differed slightly, choices also differed based on the differing perspectives. Figure 21 shows teacher responses for this item, and Figure 22 shows leadership responses for this item.

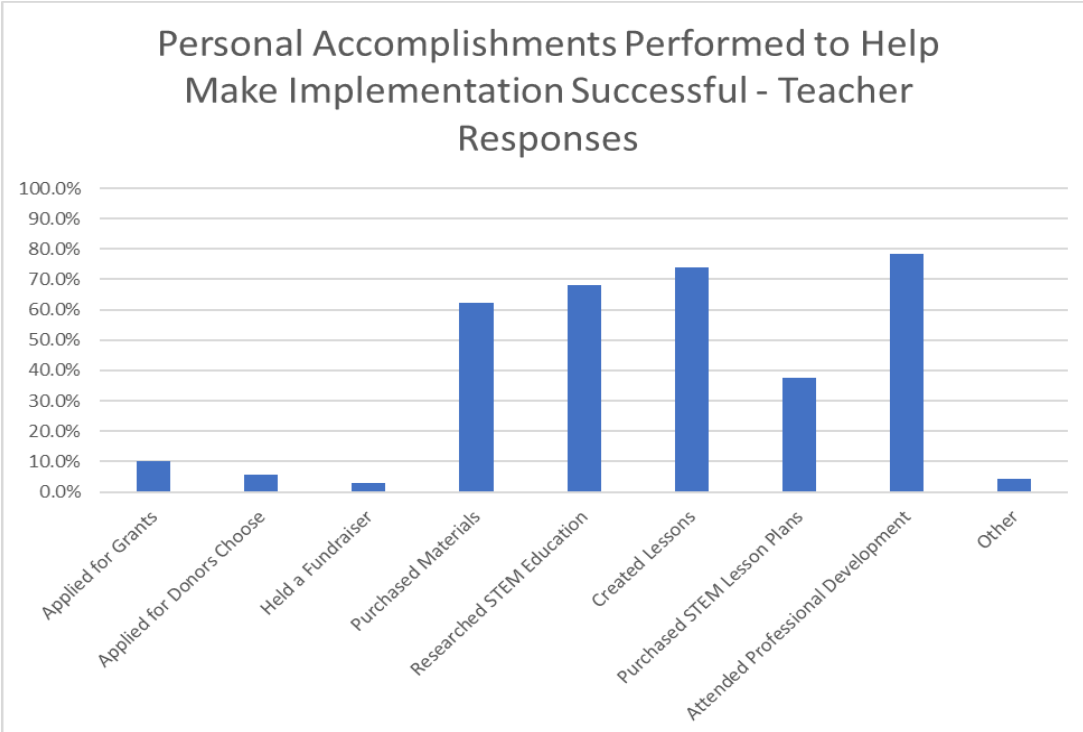


Figure 21. Teacher Responses Involving Personal Accomplishments Performed. Information found in the figure conveys teacher understanding of accomplishments performed to help make implementation of STEM innovation successful.

As shown in Figure 21, most elementary educators attended professional development concentrating on the STEM innovation. Additionally, teachers created lessons, researched STEM education, and purchased their own materials to use during STEM lessons; however, 10.1% of elementary teachers applied for federal, state, or local grants. Furthermore, quantitative data analysis revealed only 5.8% of teachers applied for additional supports through the Donors Choose avenue or held a fundraiser.

As mentioned previously, leaders examined personal accomplishments performed to help make teacher implementation successful. Figure 22 explores leadership responses for this item.

Figure 22. Leadership Responses Involving Personal Accomplishments Performed. Information found in the figure conveys a comprehensive understanding of accomplishments elementary leaders performed to help make teacher implementation of STEM innovation successful.

As shown in Figure 22, all six leadership respondents responded they helped to provided teachers STEM professional development. Also, quantitative data analysis revealed the majority of elementary leaders provided teachers with materials, a curriculum, and encouragement; though only half of the respondents replied they researched STEM education. No respondents acknowledged they helped teachers implement the innovation by providing them funding or holding a fundraiser to increase supports.

In addition to educators examining personal accomplishments performed to help implement STEM successfully, teachers and leaders also described successes in implementing STEM innovation. This fourth question was rooted in the understanding

that every educator has experienced successes in implementing STEM innovation. While the question examined a similar theme, both the teacher and leadership item differed based on the perspective of the individual; therefore, this fourth question asked teachers to describe their successes in implementing STEM innovation and leaders described their leadership team's successes in helping teachers implement STEM innovation. Since the question asked respondents to describe their successes, an explanatory schema was developed to analyze common themes. Table 43 displays the common themes found in teacher respondent descriptions of successes of implementing STEM innovation.

Table 43

Common Themes Used to Describe Successes in Implementing STEM

Successes in Implementing STEM Descriptions	Coded Variable
Students strive, students persevere, students challenge themselves, STEM empowers students, students gain experience, and students learn from their mistakes	Student Perseverance
Student creators, builders, achievers	Student Achievements
Student enjoyment, engagement, involvement, and excitement	Student Engagement
I implemented it, I am trying to improve, and I am learning from others	Personal Teacher Growth
School implementation and goal teams	School Growth
Other	Other

As shown in Table 43, six different common themes were developed based on teacher descriptions of successes in implementing STEM. Many teachers mentioned student successes in their descriptions; therefore, three different classifications involving students were used. The common themes of student perseverance, student achievement, and student engagement were used to define teacher participant descriptions. Additionally, a few teachers addressed successes of implementing the innovation in a

personal sense; therefore, any response involving the teacher and their successes in using the innovation resulted in personal teacher growth. Several respondents also described the school and how the school has succeeded in implementing the STEM innovation; therefore, responses that mentioned the school were described with the common theme of school growth. Also, a few respondents did provide successes not categorized into a common theme; therefore, these responses are described as “other.” Responses coded as “other” are described following the analysis and exploration of coded frequencies. Figure 23 displays teacher responses describing successes in implementing STEM innovation.

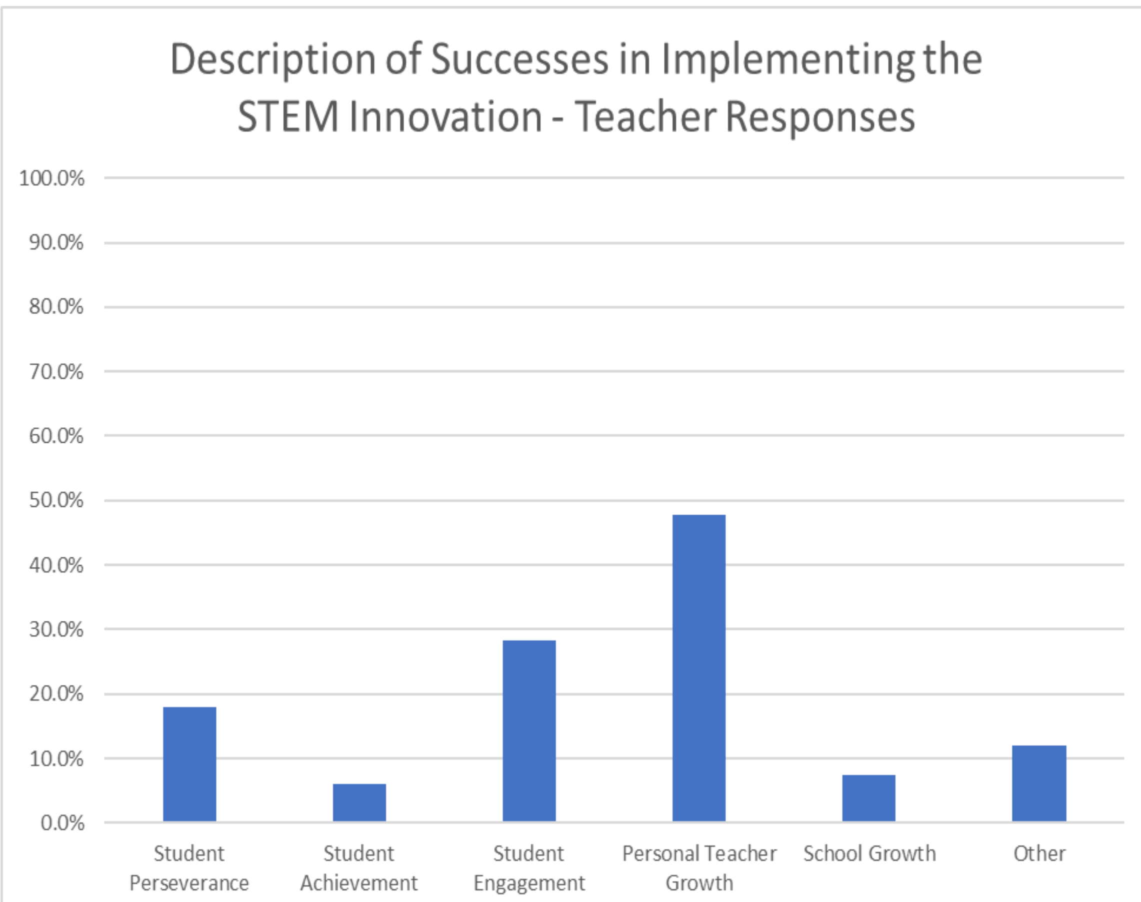


Figure 23. Teacher Descriptions of Successes in Implementing STEM. Information found in the figure conveys teacher understanding of successes elementary teachers experienced while implementing the STEM innovation.

Figure 23 shows a comprehensive understanding of elementary educator perceived successes in implementing STEM innovation. Quantitative data analysis revealed the majority (47.8%) of teacher respondents experienced personal growth during the implementation phase. Additionally, 28.5% of teacher respondents described the success of student engagement. Describing how STEM education has enabled students to become excited about learning and provided students enjoyment when STEM lessons were incorporated into student learning; however, only 17.9% of respondents described student perseverance and achievement as a success. Also, 7.5% of respondents described the school growth during the process and team creation focusing directly on the STEM innovation.

As previously mentioned, some teacher respondent descriptions of successes in implementing the STEM innovation could not be categorized with a commonly found theme; therefore, these responses were coded as "other." Table 44 depicts "other" descriptions for teacher respondents for this item.

Table 44

Teacher Descriptions of Successes in Implementing STEM "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
• Doing the best to implement the innovation, but experiences questioning of the innovation in the classroom • ELL has increments of STEM units • The focus on test scores has hindered me from stepping outside the box.	• Observation of a STEM-trained elementary teacher in action • Not easy to implement because students are on specific learning objectives • Being able to collaborate with other team members	• Depends on the lesson or activity • Have always utilized integrated learning while teaching and STEM activities (related to AIMS education)

As shown in Table 44, each school expressed successes in implementing STEM innovation not described with a common theme; however, some respondents'

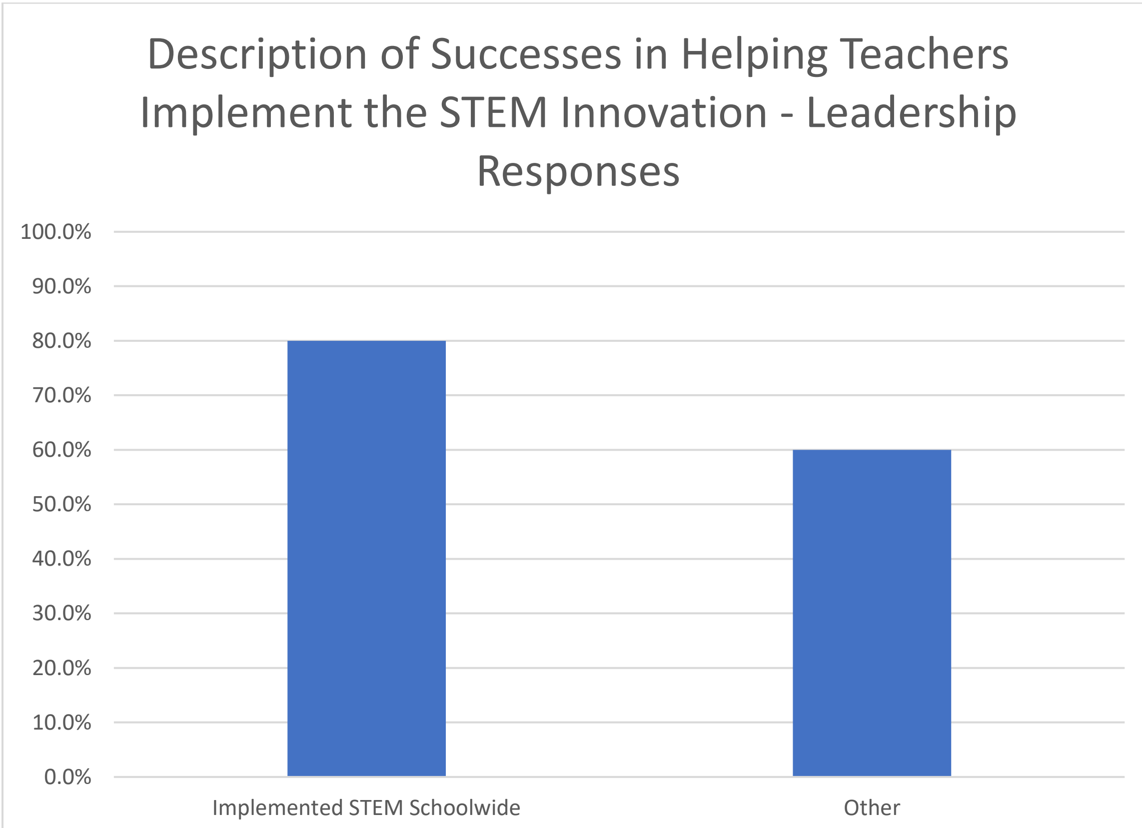
descriptions do not necessarily describe successes in implementing STEM innovation. Instead, some respondents described how they felt about the innovation. One respondent specifically described,

> I feel I am doing my best to implement the STEM initiative. However, I never know if what I am doing is "right" or technically "STEM." I have done much research in STEM and found many STEM resources, but I am repeatedly told if there is no "problem" for students to solve then I am not doing it right. I am not sure if I need more professional development or if I understand STEM to be something different from what we have made it into for our school/classroom. (Teacher Respondent, Teacher Survey Response, October 12, 2018)

Additionally, another respondent stated they do not believe they are very successful in implementing the STEM innovation because of test scores. Also, this respondent described teacher accountability is determined by student test scores, and these scores have hindered them from stepping outside their comfort box.

Previously, it was mentioned that leaders also described their successes; however, leaders focused on describing their leadership team's successes in helping teachers implement STEM innovation. However, one respondent chose not to answer the question which accounted for 16.7% of data. Additionally, leadership responses were different from those of teachers; therefore, a different explanatory schema was utilized to identify themes in leadership responses, though only one common theme was found in these responses. Therefore, the theme of implemented STEM schoolwide was used to identifiy reponses focused on implementing the innovation schoolwide. Also, a theme of "other" was utilized to describe successes not identified with a common theme.

Responses coded as "other" are described following the analysis and exploration of coded frequencies. Figure 24 shows quantitative data involving leadership description of successes in helping teachers implement the STEM innovation.



Note. One leadership respondent chose not to answer survey item resulting in 16.7% of missing cases.

Figure 24. Leadership Descriptions of Successes in Helping Teachers Implement STEM. This figure presents information concerning leaderships explanations describing their leadership team's successes in helping teachers implement STEM innovation.

As shown in Figure 24, 80% of leadership respondents described leadership team successes in helping teachers implement STEM innovation involved the coded theme of implemented STEM schoolwide. Many leaders described implementing STEM discussions in grade-level professional learning communities, while others described including the focus on the school improvement plan. Also, some leaders included the success of implementing a school goal team focusing on the STEM innovation; however,

three responses included descriptions of successes not common with other leadership members. Therefore, these three responses were categorized as "other." Table 45 depicts "other" descriptions for leadership respondents for this item.

Table 45

Leadership Descriptions of Successes in Helping Teachers "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
Feels rigor of classroom instruction approved across the school	Attended trainings personally to help encourage teacher growth and help to implement staff STEM professional development	No "other" responses identified

Table 45 describes "other" leadership respondent descriptions of successes in implementing the STEM innovation. One of the respondents mentioned they helped to implement staff professional development involving STEM; another respondent mentioned they personally attended additional professional development to help encourage teacher growth with the innovation. They described bringing their knowledge back to the teachers to help them. Additionally, another leadership respondent's answer was not related to their leadership's team successes in helping teachers implement STEM. This respondent described they feel rigor in classroom instruction has improved across the school; however, their description did not describe the leadership's team successes in helping teachers implement the innovation.

Challenges in implementing STEM. In addition to educators describing successes in implementing STEM innovation, teachers and leaders also examined challenges in implementing STEM innovation. Teachers examined challenges of implementing STEM through four questions focusing on this element. Leaders examined challenges of implementing STEM through three challenge-related questions. Each of these questions supported Research Question 3 and were rooted in the understanding that every educator

has experienced challenges in implementing STEM innovation.

The first question encouraged educators to examine one thing the leadership team could have offered to make implementation successful. Specifically, the teacher survey examined teacher perspectives of one thing the leadership team could have offered to make their implementation successful. In addition, the leadership survey examined leadership perspectives of one thing the leadership team could have offered to make teacher implementation successful. Figure 25 provides teacher and leadership respondent data describing this item.

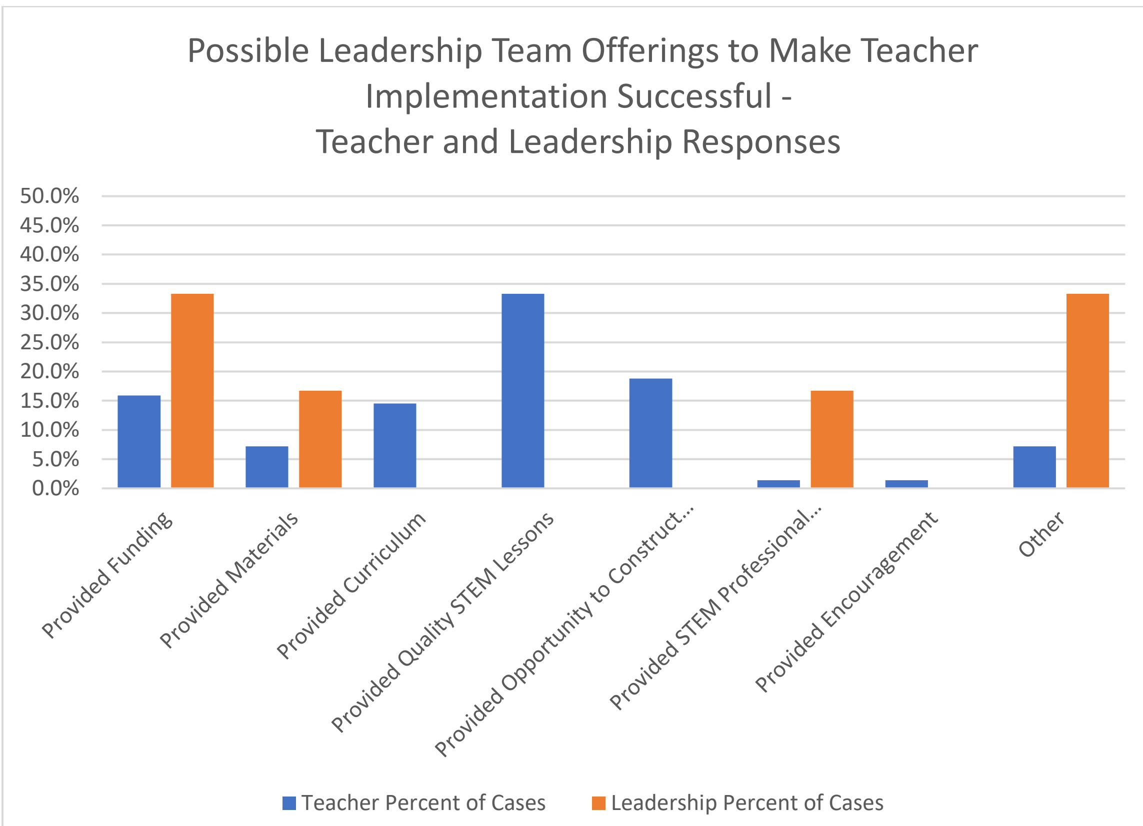


Figure 25. Teacher and Leadership Responses: Possible Leadership Team Offerings. This figure presents the percent of cases involving one thing leadership team members could have offered to make their implementation of STEM successful.

Figure 25 shows the percent of cases linking teacher and leadership perspectives

involving possible leadership team offerings to aid in successful teacher implementation of STEM innovation. Quantitative data analysis revealed 33.3% of teachers responded leadership team members could have provided teachers with quality STEM lessons in their implementation of the innovation. Also, quantitative data analysis revealed 33.3% of leadership members agreed that the leadership team could have offered teachers funding to help make STEM implementation successful.

In addition to educators examining possible leadership team offerings, teachers also examined one thing they could have accomplished to help make implementation successful. This second teacher survey question, focused on challenges, was rooted in the understanding that all educators are responsible for developing growth of an innovation; it is not only the responsibility of leaders to support growth, but also an individual's responsibility. Therefore, knowing teachers reflect upon what they could have accomplished, this question was developed to examine this reflection. Figure 26 shows teacher responses for this item.

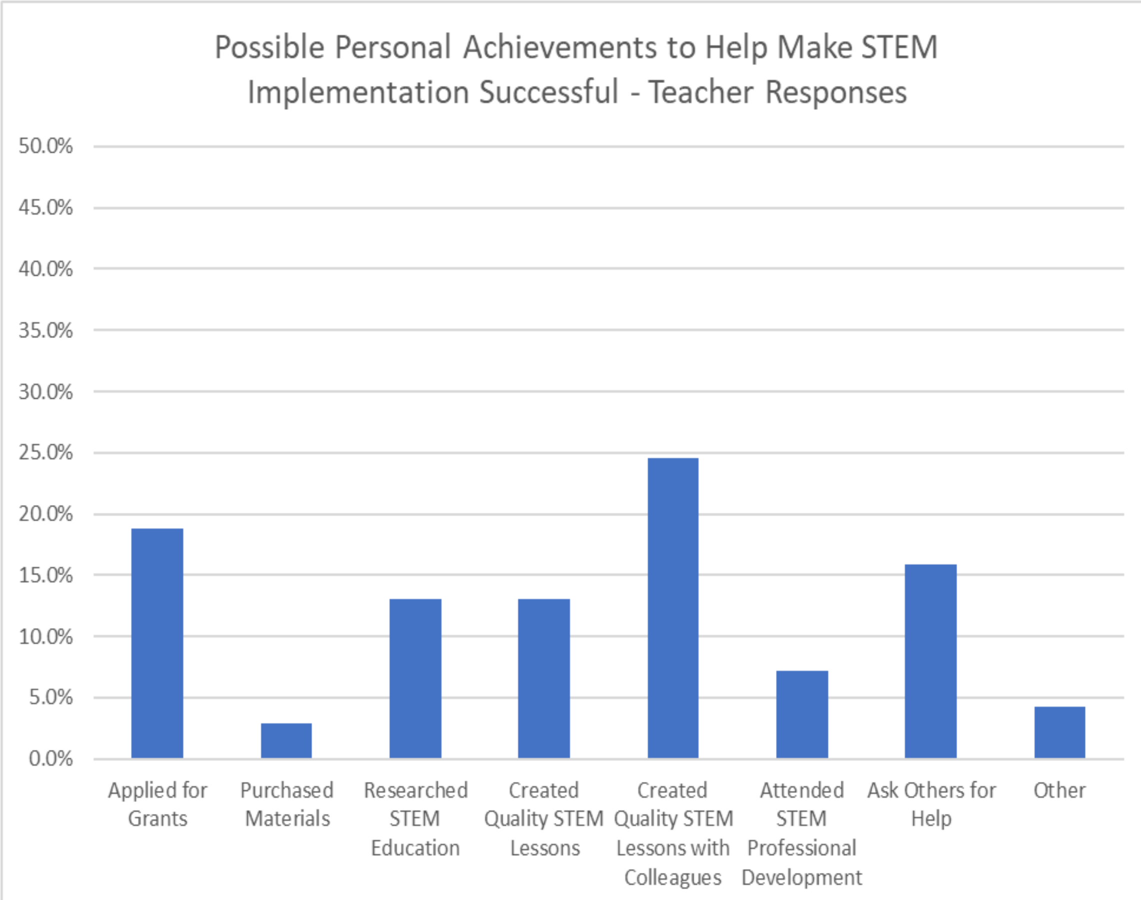


Figure 26. Teacher Responses: Possible Personal Achievements. This figure presents teacher perspectives concerning one thing teachers could have accomplished to help make their implementation successful.

Figure 26 shows frequency data concerning one thing teachers could have accomplished to help make implementation of STEM innovation successful. Quantitative data analysis revealed the majority of teacher respondents responded they could have created quality STEM lessons with colleagues to help aid in the successful implementation of STEM innovation. Additionally, less than 20% of respondents replied applying for grants could have helped them successfully implement the innovation. Also, only 15.9% of teacher respondents believe asking others for help while working through the implementation process could have helped them successfully implement the

innovation. Furthermore, 13% of teacher respondents responded either researching STEM education or creating quality STEM lessons could have helped them successfully implement STEM. Data analysis also revealed fewer teacher respondents replied purchasing materials could have helped made their implementation successful.

In addition to teachers describing what they could have accomplished to help make their implementation successful, teachers and leaders also examined the top three most important challenges faced when implementing STEM innovation. This survey question supported Research Question 3 and was rooted in characterizing the top three challenges elementary educators face when implementing STEM. Figure 27 shows teacher and leadership responses for this first item.

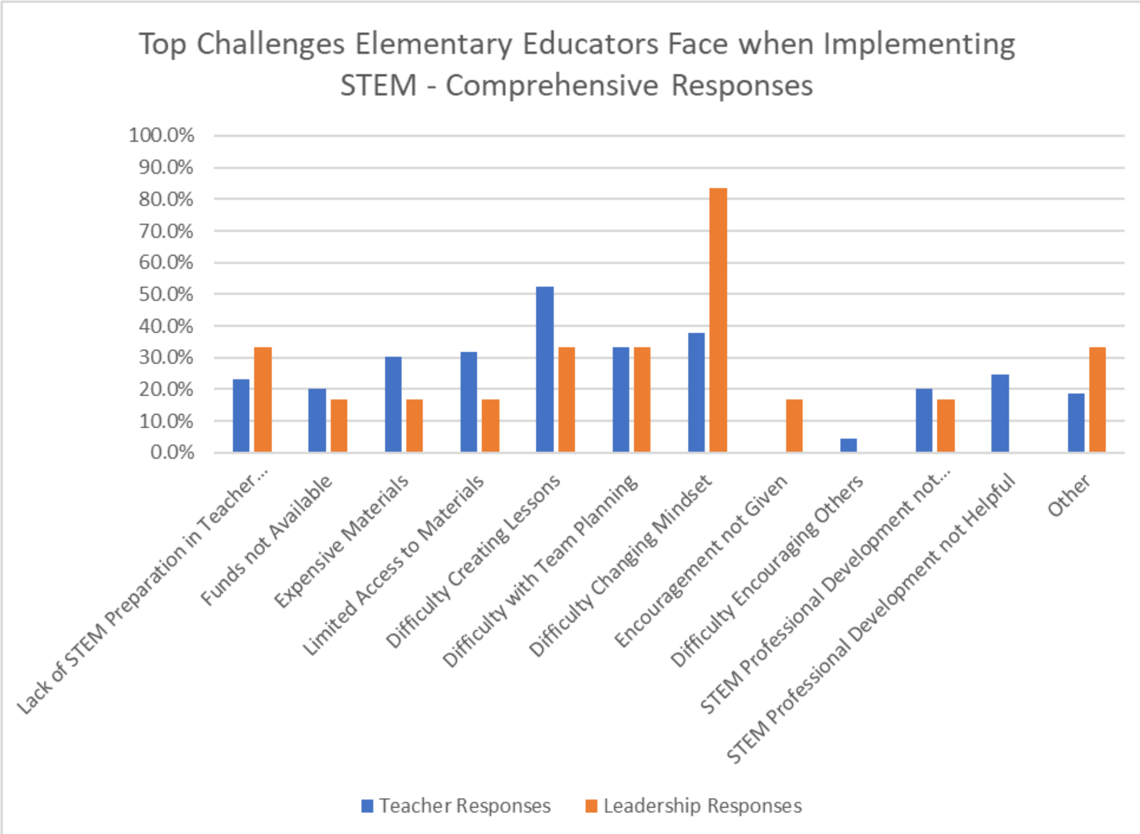


Figure 27. Top Challenges Implementing STEM Innovation. This figure presents teacher and leadership perspectives involving challenges elementary educators face when implementing the STEM innovation.

Figure 27 shows quantitative data analysis examining top challenges elementary educators face when implementing the STEM innovation. Data revealed the majority of teacher respondents responded the top three challenges elementary educators faced when implementing the STEM innovation involved difficulty in creating lessons, difficulty in changing mindset, and difficulty in team planning. Similar to teacher respondents, leadership respondents also examined the top three challenge elementary educators faced when implementing the STEM innovation. Leaders responded the top challenge involved changing mindset; however, data also revealed leadership respondents could not characterize only three important challenges. Instead, leadership quantitative data

revealed four challenges elementary educators faced when implementing STEM innovation. Data showed the other most important challenges elementary educators faced when implementing the innovation involved a lack of STEM preparation in the teacher education program, difficulty in creating lessons, and difficulty in team planning.

In addition to educators examining important challenges elementary educators face when implementing STEM innovation, teachers and leaders also examined specific challenges associated with implementing STEM. This question was rooted in the understanding that every educator has experienced challenges in implementing STEM innovation. Since, the question asked respondents to describe their challenges, an explanatory schema was developed to analyze common themes. Table 46 displays the common themes found in teacher respondent descriptions of successes of implementing STEM innovation.

Table 46

Common Themes Describing Challenges in Implementing STEM

Descriptions of Challenges in Implementing STEM	Coded Variable
Time to teach, time to plan, time to implement, time to organize lessons	Time Challenge
Unprepared, not sure how to implement, not sure if we are doing STEM, not understanding what STEM is, not enough information, not sure how to use STEM	Unprepared
Hard to change mindset	Altering Mindset
Overwhelmed in implementing the innovation, overwhelmed with learning the innovation, overwhelmed	Overwhelmed
Lack of resources, lack of STEM support, limited access to lessons, limited resources, lack of funding, lack of lessons, lessons not designed for younger grades, limited lessons for younger grades, supplies expensive	Lack of Resources
Professional development not aligned, professional development not appropriate	STEM Professional Development Challenge
No challenges	No Challenges in Implementation
Other	Other

Table 46 describes common themes found in the description of challenges in implementing the STEM innovation. Many respondents mentioned they were challenged with time in some capacity, whether that challenge was in teaching, planning, organizing, or implementing; therefore, if respondents described a challenge with implementing STEM involving time, the coded variable of time was utilized. Additionally, respondents also described being unprepared to implement the innovation as well as expressed concern over not being sure how to implement the innovation and not understanding the innovation fully; therefore, should respondents describe confusion over STEM innovation in their description of challenges associated with implementing STEM, the coded variable of unprepared was applied. Also, a few respondents described the challenge of changing the mindset from one that was centered around traditional practices to a mindset

that focused on the active learning approach of STEM education; therefore, if a respondent described a challenge associated with changing mindset, the coded variable of altering mindset was employed. Furthermore, a small number of respondents expressed a challenge of being overwhelmed with learning the innovation and implementing it as well as being overwhelmed with the requirements and interruptions in the daily schedule of the elementary classroom; therefore, if a respondent described a challenge associated with being overwhelmed, the coded variable of overwhelmed is used. Also, many respondents described a lack of STEM resources in their description of challenges. Many respondents included challenges relating to lack of funding, lessons, and supplies. Also, respondents described there was limited access to lessons, limited resources for younger students, or available lessons not designed for younger grade levels. A few also mentioned supplies were expensive; therefore, should a respondent describe a challenge associated with resources or support, the coded variable of lack of resources was exercised. Additionally, a few respondents admitted a challenge concerning STEM professional development. Should a respondent describe a challenge associated with professional development not aligned to the elementary level or not appropriate for younger grades, the coded variable of STEM professional development was applied. Also, a small number of respondents also expressed they had no challenges in implementing STEM innovation; therefore, the coded variable of no challenges was utilized for these respondents. Furthermore, some respondents described challenges not found in a common explanatory schema with other respondents' descriptions; therefore, the coded variable of "other" was placed on these descriptions. Responses coded as "other" are described following the analysis and exploration of coded frequencies.

Once themes were developed, each respondent's description was coded according to the coded variables; however, many respondents' descriptions of challenges mentioned more than one coded variable in the response. Therefore, multiple themes could be found in a respondent's description of challenges. Figure 28 shows coded teacher and leadership respondent data of challenges associated with implementing STEM innovation.

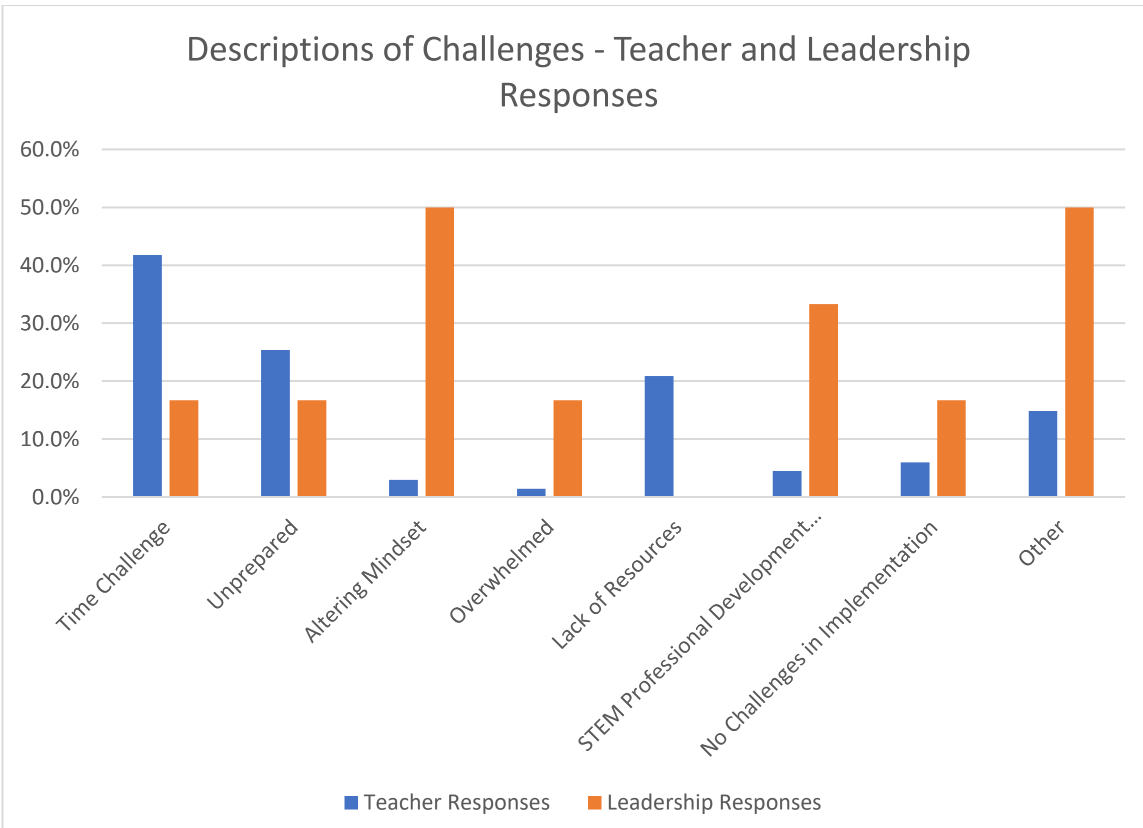


Figure 28. Descriptions of Challenges in Implementing STEM Innovation. This figure presents teacher challenges in implementing the innovation and leadership challenges in helping teachers implement the innovation.

Figure 28 compares both teacher and leadership perspectives involving the challenges of implementing STEM innovation. The teacher survey examined respondents' descriptions of challenges in implementing STEM innovation. Quantitative

data analysis revealed the majority of teachers are challenged in the area of time when implementing STEM. Many of these educators expressed finding time to research, plan, teach, and implement the innovation was difficult. Also, 25.4% of teachers and 16.7% of leaders described being unprepared to implement STEM, and 20.9% of teacher respondents also described a lack of STEM resources hindering them when implementing the innovation. Many of these respondents described STEM resources as being limited or not designed for younger elementary students. The leadership survey examined respondents' descriptions of challenges in helping teachers implement the innovation. Quantitative data analysis revealed the majority of leaders described it was a challenge encouraging teachers to shift their mindset towards instructional practices that are unfamiliar.

As previously mentioned, some educator respondents' descriptions of challenges in implementing STEM innovation could not be categorized with a commonly found theme; therefore, these responses were coded as "other." Table 47 depicts "other" descriptions for teacher respondents.

Table 47

Teacher Descriptions of Challenges in Implementing STEM "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
• Scheduling and creating STEM-based activities • Students lacking the prior knowledge needed to progress through self-guided learning • Creating motivating lessons • Changing the language used in the classroom to one that utilizes STEM-based vocabulary	• The difficulty with student communication and teaching them how to be productive, useful, and good communicators to benefit the group	• STEM is an overhaul of the curriculum • Encouraging teachers to co-teach STEM lessons with them as many teachers view STEM as one more thing to do in the instructional day • STEM is mainly a middle and high school curriculum • Hard for younger students • Struggled to make lessons age appropriate

Table 47 describes "other" teacher respondent descriptions of challenges in implementing the STEM innovation. All three elementary schools expressed respondents describing challenges involved in implementing STEM innovation not identified with a common theme. Responses categorized with the "other" label differed in that some responses focused on personal implementation of the innovation, while others focused on the education aspect of implementing the innovation and how it has impacted curriculum and students.

As previously mentioned, some leadership respondent descriptions of challenges in implementing the STEM innovation could also not be categorized with a commonly found theme; therefore, these responses were coded as "other." Table 48 depicts "other" descriptions for leadership respondents.

Table 48

Leadership Descriptions of Challenges in Implementing STEM "Other" Category

Heritage Elementary	Old Mountain Elementary	Louis Armstrong Elementary
No "other" responses identified	STEM is very broad and determining how to chunk STEM professional development can be challenging and encouraging teacher buy-in can be challenging	Does STEM take away from core instruction

Table 48 describes "other" leadership respondent descriptions of challenges in implementing the STEM innovation. Only two elementary schools expressed descriptions of challenges in implementing STEM innovation not identified with a common theme. One leadership respondent at Old Mountain Elementary mentioned STEM is very broad and determining how to chunk STEM professional development is a challenge. Furthermore, the respondent also described that encouraging teacher buy-in to the innovation also presented a challenge. The leadership respondent at Louis Armstrong Elementary described a challenge in helping teachers implement the STEM innovation involved questioning does it take away from core instruction. It is unknown if the respondent was describing this as a teacher attitude or their own personal opinion.

Focus group data. Focus group sessions were conducted at each of the three elementary schools involved in the study to gain an understanding of the successes and challenges in implementing the STEM innovation. All four focus group sessions involved two items focusing on Research Question 3, "How do elementary educators characterize successes and challenges in implementing the STEM innovation"; however, teacher and leadership participants were asked differing questions based on the differing perspectives.

The first focus group item supporting this research question was rooted in the understanding that when implementing STEM, successes will be found; therefore, the

question was shaped to examine perspectives of both teachers and leaders. Teachers were asked to describe their successes in implementing STEM. Likewise, leaders were asked to describe what the leadership team accomplished to encourage teachers to implement STEM successfully. Table 49 displays a quantitative breakdown of the teacher focus group sessions, and Table 51 displays a quantitative breakdown of the leadership focus group session.

Table 49

Quantitative Breakdown Teacher Focus Group Responses–STEM Successes

Coded Theme	Referenced by Teachers
Building Confidence	8
Making Connections	2
Student Engagement	2
Collaboration	2

Table 49 reveals a quantitative breakdown of the teacher focus group item focusing on STEM successes. In analyzing the focus group data, five themes emerged focusing on successes found in implementing STEM. Some specific quotes supporting these supports are explored in Table 50.

Table 50

Teacher Focus Group Responses-Successes in Implementing STEM

Coded Theme	Supporting Quote
Building Confidence	"Watching the child who just usually sat there and did not do a whole lot, come out of their shell, to come out and participate in a product. Yeah. Be the superstar that they have not yet been." "I think it helps their confidence level too. Some kids are not confident to raise their hand during whole group or even during small group. They are not confident when they read. They are not confident in math. So, when you are doing the brainstorming process, and they are raising their hand, and they are saying some outlandish stuff, and then they follow through with that plan and you get to that part where they are reporting out, and they say, "This work was awesome." I am like, "You know what, good for you. You can stand up in front of the class and speak," and before you were the kid that was not going to raise your hand. So, I think as that helps them, it translates into other areas of the classroom, so their confidence in themselves builds, which is going to make them excited to learn in other areas too.
Making Connections	"Well, like some of the answers my kids come up with. Like one, in particular, she will say something, and I am like, "Dang," like I would not have even thought about that. I mean sometimes they come up with answers that you do not expect a seven-year-old to come up with."
Student Engagement	"I think just the fun that they have. As a teacher, you think about, "Well, this is going to be a disaster. My room is going to be a mess. They are going to go crazy," and they do and your room is a mess, but they love it, and they are engaged in it. I think at the end of the day, we have so much fun taken out of school and [STEM] is something fun that we kind of put back in it."
Collaboration	"I would say collaboration, one between teacher and students, and student and student, and teachers to teachers. I feel like that collaboration piece, I mean some of them will bring you to tears when you see how students work together, no matter what their disability is or what their level is, you would never know because it is just amazing. Even teacher to teacher, the connection that they make."

Table 50 displays some supporting quotes focusing on successes found in implementing STEM. The data revealed teachers are experiencing success in their classrooms when implementing STEM. Teachers describe many student successes and many different ways success can be achieved for the students.

As previously mentioned, leaders were also asked to examine successes of implementing STEM. Leadership perspectives involved leaders examining what the leadership team accomplished to encourage teachers to implement STEM successfully.

Table 51 displays a quantitative breakdown of the leadership focus group session examining this item.

Table 51

Quantitative Breakdown Leadership Focus Group Responses–STEM Successes

Coded Theme	Referenced by Leadership
STEM School Visits	2
Professional Development	2
STEM Goal Teams	2
Following a STEM Plan	3
Other	4 (Co-teaching, Reaching out Locally, Connecting STEM to Careers, Addressing Feedback)

Table 51 reveals a quantitative breakdown of the leadership focus group item focusing on STEM successes. In analyzing the focus group data, five themes emerged related to encouraging teachers to implement STEM successfully. Some specific quotes supporting these supports are explored in Table 52.

Table 52

Leadership Focus Group Responses–STEM Successes

Coded Theme	Supporting Quote
STEM School Visits	"We went to other STEM schools. To find out what was working and what was not."
Professional Development	"We partnered with [professional learning center]."
STEM Goal Teams	"We focus on STEM in our PLCs and have a STEM team that makes sure grade level members are also focusing on the innovation."
Following a STEM Plan	"We started small. We also had a good plan from the start. We did not just say; we are going to do the STEM thing. We really mapped out STEM. We met with the [STEM education professional development trainers] and partnered with them and developed a plan for year by year. So, by the end of year one, we decided this is where we would like to be. Year two, here is what where would like to be. Year three, and so on. As a leadership team, we sat down and mapped out strategically."
Other	"I would say maybe the motivation piece. We recently had the idea to reach out to local farms to talk about lagoons and how to protect them, and places like the fire station to talk about heat transfer. Doing on-site problem-based learning and when we share those out, I think it gets people excited, and it gets their minds working. So, I think what we have done successfully is now we have several people in our building thinking. "Okay, what could I do with my students? Moreover, where could I take them? How could I relate to it?" I think that helps with not only the career piece but just knowing what goes on behind the scenes as you pass a business. "What do they encounter? What problems do they have? How does it apply to what I am learning?" It encourages other grade levels to become involved and encourages other teams to start talking about where they could go, and what they could do with their kids."
	"Student engagement and excitement. Students are going home and talking about it with their parents. Especially kids who typically are not engaged. Teachers see that too, and that also helps them see that this is the type of learning that these kids need, [it] motivates them. Now we have grade levels that are partnering with other grade levels to do those things together to build those student leadership pieces as well."

Tables 52 displays leadership perspectives involving the examination of successes in encouraging teachers to implement STEM. Data revealed to encourage teachers to succeed in implementing the innovation, schools started with a plan and carried it through; however, school leaders also had to learn as they progressed through implementation and began to partner with businesses and community members to also encourage teacher support and growth. This support led to opportunities for teachers to further implement the innovation and build an understanding of the innovation.

The second focus group item supporting this research question was rooted in the understanding that when implementing STEM, challenges can also be found; therefore, the question was shaped to examine perspectives of both teachers and leaders. Teachers were asked to describe their challenges in implementing STEM. Likewise, leaders were asked to describe what challenges they noticed when encouraging teachers to implement STEM. Table 53 displays a quantitative breakdown of the teacher focus group sessions, and Table 55 displays a quantitative breakdown of the leadership focus group session.

Table 53

Quantitative Breakdown Teacher Focus Group Responses–STEM Challenges

Coded Theme	Referenced by Teachers
Different Understandings of STEM	2
Materials	2
Funding	3
Time Management	6
Teachers had to find own Professional Development	3
Time to see Success	2
Adapting Lessons to fit Grade Level	2
Challenge with Professional Development	3
Reluctant to give up Tradition	2
Challenging for Students who Struggle Academically	2
Finding the Benefit	5
Other	4 (Planning, Challenge with Number of Students, Challenging for Younger Students, Letting go)

Table 53 shows a quantitative breakdown of the teacher focus group item focusing on STEM challenges. In analyzing the focus group data, 12 themes emerged

focusing on challenges found in implementing STEM. Data revealed the top challenges when implementing STEM innovation existed in funding, time management, challenge with professional development, finding the benefit, and "other." Some specific quotes supporting these top challenges are explored in Table 54.

Table 54

Teacher Focus Group Responses–Challenges in Implementing STEM

Coded Theme	Supporting Quote
Funding	"Materials, you always need materials, and it does add up."
Time Management	"I think one of the biggest challenges is time constraints. We have so much that we juggle and we have so much that we want to do and accomplish with our students, but also, we are required to meet specific expectations when it comes to state testing and accountability**.** I just wish there was more time. Moreover, I think that may be a bit of a concern."
Teachers had to find own Professional Development	"Teachers had to find their own professional development to go to."
Challenge with Professional Development	"We have gotten some professional development and at times it would say it was elementary-centered, but it was not. We have been frustrated because it is a little more developed for higher grades."
	"We have had some trainings and they said STEM was this and then the next training they would say something different. It was very confusing. So all the training that we did not necessarily consistent and that causes a lot of confusion."
Finding the Benefit	"How is STEM going to help kids on state test? Sadly, STEM practices are not what assessments at based on at the end of the school year."
	"Our grade at the end of the year and whether we keep our job or not depends on how many of our kids are proficient and how many of them meet or exceed growth. So, when I am thinking about my lessons, I am thinking about STEM, but then in the back of my mind it is always there, I also have to make sure this stuff is equally as important because I want to make sure my kids are where they are supposed to be at the end of the year."
Other	"Very scary, we had to implement something we did not know how to do, or exactly what it was. That kind of goes back to the different definitions of what it is. So, you are trying to figure it out. That is a very difficult job to do when there are so many definitions of what it is. You want to do it right; you want to do what you are supposed to do, you want to make the children successful, you want the school to be best. So, it is the fear of the unknown."

Table 54 displays some specific quotes from teacher focus group sessions

focusing on challenges in implementing STEM. While teachers focused on student successes when discussing successes of implementing STEM, teachers focused on personal experiences when discussing challenges. For many teachers, the end-of-grade testing is a primary focus. While teachers consider STEM as a means to create student success, the inquiry-based active learning approach to acquiring knowledge is not how end-of-grade assessments are formatted. Also, teachers have experienced frustration in regard to the professional development received. Different professional development instructors differ over their understanding of STEM, and these different opinions have led to confusion among teachers.

As previously mentioned, leaders were also asked to examine challenges; however, these individuals examined challenges they noticed when encouraging teachers to implement STEM. Table 55 displays a quantitative breakdown of the leadership focus group session.

Table 55

Quantitative Breakdown Leadership Focus Group Responses–STEM Challenges

Coded Theme	Referenced by Leadership
Teachers do not like to take risks	2
Ownership (Buy-in)	4
STEM is Something else to do	2
Other	4 (Thought of STEM as Separate, Aligning STEM Lessons to Curriculum, Teachers Believe they do not have Time, Only STEM Teacher Should Teach STEM)

Table 55 shows a quantitative breakdown of the leadership focus group item focusing on STEM challenges. In analyzing the focus group data, five themes emerged focusing on challenges found in implementing STEM. Some specific quotes supporting these challenges are explored in Table 56.

Table 56

Leadership Focus Group Responses–Challenges in Encouraging Teachers

Coded Theme	Supporting Quote
Teachers do not like to take risks	"I think another challenge is when staff is motivated, or they are willing to try something, but they do not know what it looks like, they wait for someone to tell them." I think that has been a challenge too. You know as a leader you do not necessarily want to tell them what to do, or how to do everything, or what everything should look like. You want people to figure that out and try."
Ownership (Buy-in)	"Helping people find value, clarifying what it can look like and letting other people take ownership of that piece to advertise what we can do with it. Then slowly see those changes trickle through all the grade levels."
STEM is Something else to do	"STEM is part of what we do. For me, that was the biggest challenge was getting away from it being something else to do. Teachers are already doing STEM, they just did not know they were."
Other	"The challenge, in the beginning, was okay, I have got to do a STEM activity now. What am I going to do? Some would just grab something and doing it just because they had to do it. I do not think we have a whole lot of those challenges now because we have everybody on board. Everybody is doing it. They are doing it naturally, but at the beginning that was the big piece, making sure it was aligned."

Table 56 provides supporting quotes focusing on leadership perspectives of challenges noticed when encouraging teachers to implement STEM. For one participant, encouraging all teachers to implement STEM, and not just a STEM teacher, posed a challenge because some teachers thought this individual should be the one to utilize STEM instructional practices; however, this teacher should not be the only teacher or the only time students should work through STEM (Leadership focus group participant, personal communication, November 29, 2018). Other participants agreed with this pronouncement, stating,

> Originally, we wanted a STEM teacher, and then we visited [a state STEM recognized school], and their STEM teacher was the district lead with their million-dollar grant. Her frustration at that point was the grant runs out at the end of the year and now [the STEM teacher] is helping the teachers implement STEM

> because now the teachers have to be the ones implementing the instructional practices and getting them to buy-in is challenging. After hearing [the STEM teacher] talk, I know we are doing it the right way by having teachers do it and not a STEM teacher. (Leadership focus group participant, personal communication, November 29, 2018)

Other participants agreed with this school leader and acknowledged teachers need to own it; they need to have buy-in for the implementation to be successful; however, because STEM education can mean different things for different schools based on demographics of the area, some teachers do not understand what it is supposed to look like and therefore need someone to show and tell them. Nevertheless, one leadership participant acknowledged they do not want to tell teachers exactly what STEM will be for their school or how it should look in teachers' classrooms; they would like for teachers themselves to figure that out and try (Leadership focus group participant, personal communication, November 29. 2018).

Support for implementation of STEM innovation. Research Question 4, "To what extent are elementary educators supported in their implementation of the STEM innovation," was shaped to address perspectives of current supports received. Through this research question, the researcher acquired an understanding of supports received encouraging educators to successfully implement STEM innovation. To achieve this understanding, the researcher collected quantitative data from a teacher and leadership survey as well as qualitative data from teacher and leadership focus groups.

This question's importance in the study finds its roots in the literature review, with the understanding that different supports are needed to implement innovation that is

unfamiliar. Additionally, these four supports (funding, changing mindsets, resources, and professional learning – addressed as professional development in the survey) were used as a guide to structure the educator surveys.

Through this research question, the researcher examined gaining an understanding of current supports received for the STEM implementation process. The success of the STEM innovation depends on a shared vision of support which can be developed through the combined efforts in the creation of the school's mission and vision statements. When implementers encourage a shared vision, support for the innovation can be distributed and planning for the innovation can begin (Hall & Hord, 2015); however, this shared vision of support needs to be maintained, and many resources are needed to foster and support a collective vision that will encourage change in innovation (Hall & Hord, 2016).

Survey data. As previously mentioned, each of the three elementary schools involved in the study have been implementing the innovation for a couple of years; however, each school began the journey at different times. Additionally, each school has experienced differences in supports along the way. These differences have impacted supports received. To gain an understanding of supports received during the STEM implementation process, the researcher collected quantitative data from a teacher survey and a leadership survey as well as qualitative data from teacher and leadership focus groups. Both teacher and leadership surveys included questioning centered around the four supports (funding, growth mindset, resources, and professional development); however, questioning among the two educator surveys differed based on the job title of the respondent. Table 57 displays the alignment between the surveys and Research Question 4.

Table 57

Educator Survey Alignment to Research Question 4

Research Question 4 Component	Aligned Items in Teacher Survey	Aligned Items in Leadership Survey
Funding	37 (Dichotomous Response) 38 (Open-Ended Response)	35 (Dichotomous Response) 36 and 37 (Open-Ended Response)
Growth Mindset	39 and 41 (Dichotomous Response) 40 and 42 (Open-Ended Response)	38 (Dichotomous Response) 39 and 40 (Open-Ended Response)
Resources	43 (Dichotomous Response) 44 and 45 (Multiple Response)	41 (Dichotomous Response) 42 (Multiple Response)
Professional Development	46 (Dichotomous Response) 47 (Multiple Response)	43-45 (Numerical Response) 46 (Multiple Response)

Table 57 displays aligned questions found on both the teacher and leadership surveys. Each question was formed with supports for STEM innovation in mind. To support Research Question 4, 11 survey questions were developed and analyzed for the teacher survey. Similarly, 12 survey questions were developed and analyzed for the leadership survey. Each question differed in format based on the type of feedback required.

Funding. Federal support for the STEM innovation can be found through many acts; however, it can also be found in financial areas. Funding for STEM innovation has increased over the years. In 2009, the Obama Administration provided $260 million to fund the innovation to increase American students' achievement in math and science (Charette, 2012; The White House: Office of the Press Secretary, 2009). In 2017, the Trump administration provided steady funding for the innovation. Unfortunately, the "Department of Education grant program dedicated to STEM has been replaced with a broader state grant program that is receiving less than a quarter of the funding" (American Institutes of Physics, 2017, para. 1).

Even with an increase in federal funding for the innovation, laws allow various

organizations to handle the proposed allotted money in various ways, and funds maintain more than just the STEM innovation (Iversen, 2017); however, the Department of Education has requested states use federal money to increase STEM education of students of lower economic demographics. As previously mentioned, two schools involved in the study are considered Title I schools. Based on demographics, this title signifies these two schools as lower economic; however, the federal government noted many states do not disperse funds equally across the state (U.S. Department of Education, 2011).

Additionally, the federal government urged states to use money allocated for STEM to purchase materials and devices and train educators in using the STEM innovation (Camera, 2016); therefore, the first part of survey section five involved asking educators if their school received funds for implementing the innovation and how funds were used. When addressing the teacher survey, one additional question was utilized to gain an understanding of teacher perspectives involving how they deemed their schools used allowed STEM funds. This question required respondents to provide an explanation describing how funds for the innovation were used. Since the item required respondents to provide an explanatory response, coded variables needed to be utilized. Table 58 provides descriptions of how funds were used as well as applied coded variables.

Table 58

Educator Descriptions Involving the Use of STEM Funds

Descriptions of how STEM Funds were Used	Coded Variable
Outdoor classrooms, STEM learning areas, school greenhouse, Makerspace, grow wall	STEM Learning Areas
Materials, 3D printer, supplies, resources	Resources
Do not know, have no idea	Do not know how funds were used
Used for STEM and all things STEM	Other

Table 58 presents coded variables used to describe teacher perspectives involving how school funds were used in implementing the STEM innovation. The researcher identified four coded variables based on explanatory schema found in teacher responses. The coded variable of STEM learning areas was used to explain different learning areas the school created with provided funds. The coded variable of resources was used to explain the purchase of STEM materials, supplies, resources, and a 3D printer. Additionally, some respondents replied their school received funds for implementing the innovation; however, these individuals did not know how the school utilized the provided funds. Therefore, the coded variable of do not know how funds were used was applied to these individual's responses. Also, a few teacher respondents provided descriptions of how funds were used not common with other respondents; therefore, the coded variable of "other" was used. Responses coded as "other" are described following each school's frequency data analysis and exploration. Figure 29 explores teacher perspectives involving the items "Has your school received funds for implementing the STEM innovation" and "How were those funds used."

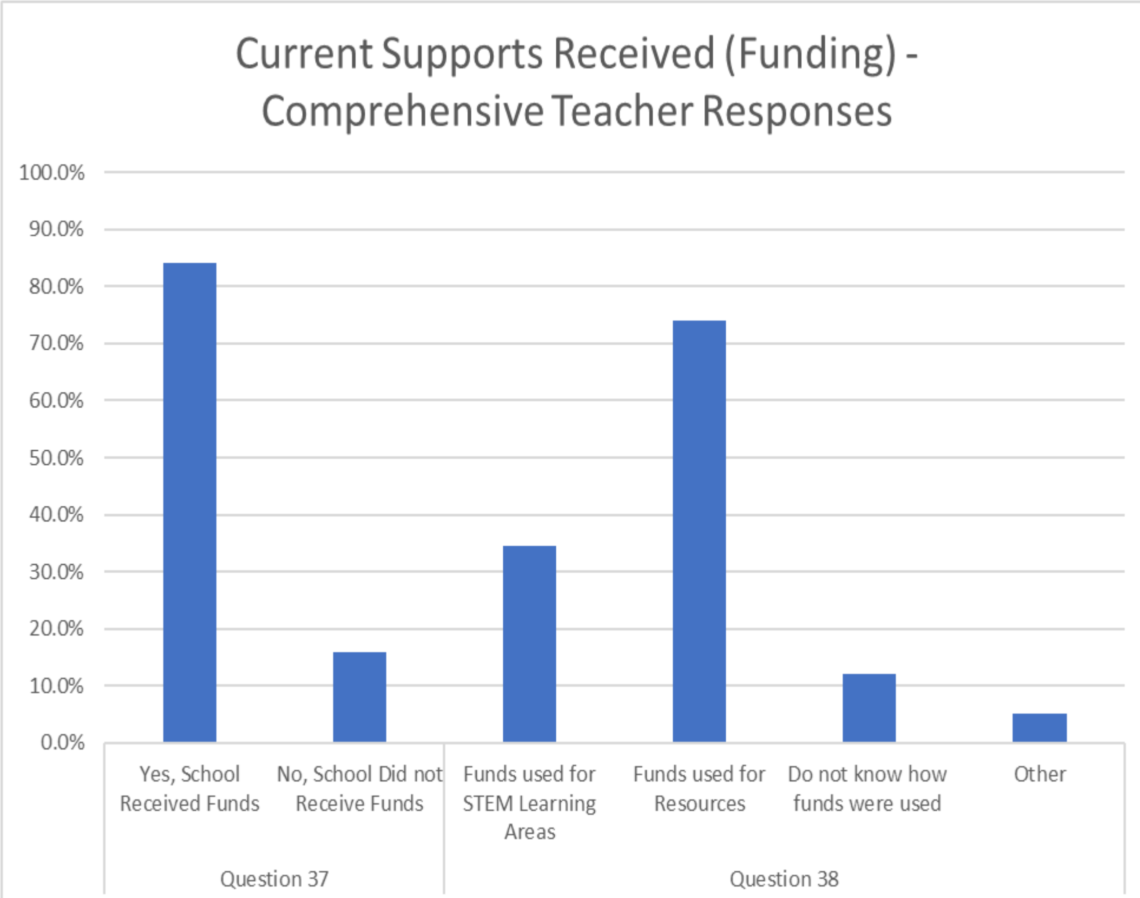


Figure 29. Teacher Responses: Current Supports Received in Funding. This figure presents an understanding of teacher perspectives involving current funding in implementing the STEM innovation.

Figure 29 presents data concerning teacher perspectives focusing on funding in implementing the STEM innovation. Quantitative data analysis revealed the majority of teachers replied the school received funds for implementing STEM innovation; however, 15.9% of teachers responded the school did not receive funds. Of those who replied the school received funds, the majority responded funds were used for resources and 34.5% replied funds were used towards STEM learning areas.

Similar to the teacher survey in which respondents were asked if the school received funding for implementing STEM innovation as well as providing descriptions

concerning how funds were used, the leadership survey also examined leadership respondents' responses to these questions; however, an additional third question was asked of leadership respondents. This additional item asked respondents to describe from where funds were received. Figure 30 explores leadership perspectives involving these three items.

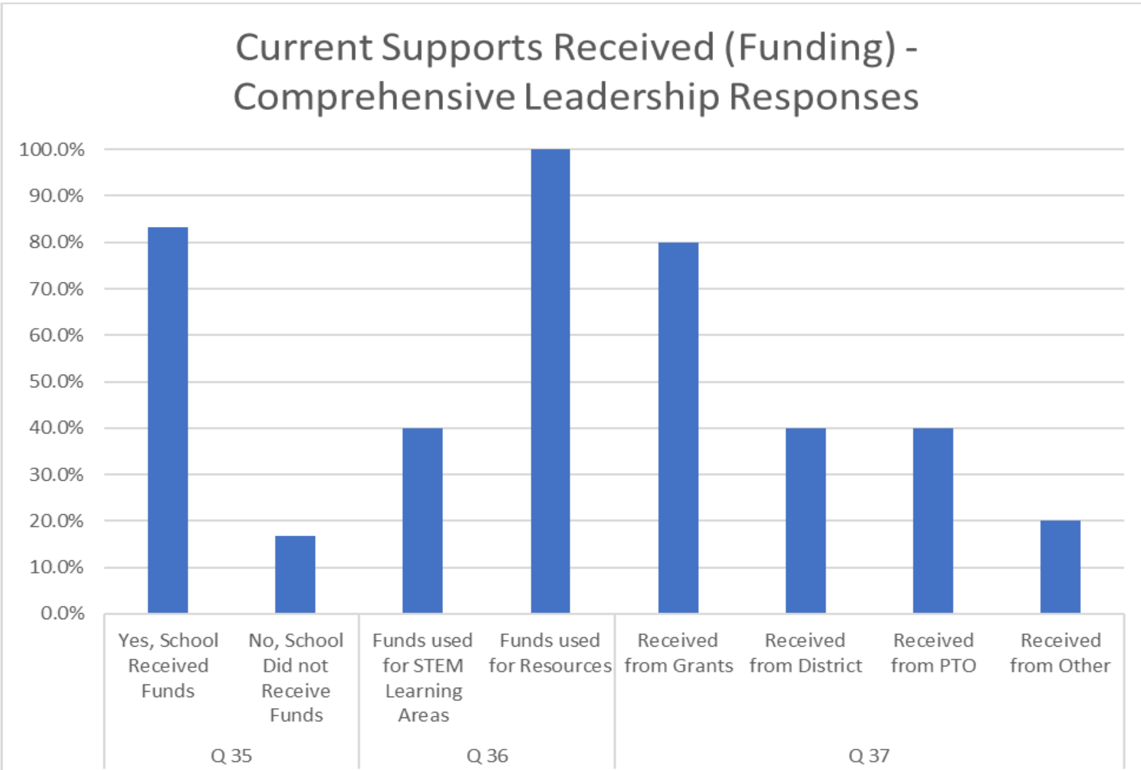


Figure 30. Leadership Responses: Current Supports Received in Funding. This figure presents a comprehensive understanding of leadership perspectives involving current funding in implementing the STEM innovation.

As shown in Figure 30, the majority of leaders replied the school did receive funding for the innovation; however, 16.7% of leaders replied the school did not receive funding. Of those who stated the school received funding for the innovation, 40% described funds were used towards creation of STEM learning areas for the school. Additionally, 100% mentioned funds were used towards the purchase of STEM resources

(materials or professional development), which is consistent with teacher responses. When asked from where funds were received, the majority of responses provided financial support was achieved through grants; however, a few respondents replied funds were received from the district (40%) or were provided through the school's PTO (40%).

Growth mindset. In addition to educators examining current funding for the innovation, teachers and leaders examined the support of growth mindset. These questions were rooted in the understanding that the mind can influence whether an individual can grow and learn through determination and persistence. In particular, when educators restructure their current instructional practices already in effect, effort and a positive attitude from the educator are needed. This effort and positive attitude are needed to encourage educators in shifting current practices and strategies beyond their comfort zone (Makela, de Miranda, 2017). As previously mentioned, Glickman et al. (2018) stated some educators "have greater capacities than others to adapt to or change the classroom and school environment" (p. 64). Educators who can express this greater capacity or willingness to adapt to change, display the growth mindset needed to expand and develop an understanding of the STEM innovation; therefore, the support of growth mindset was used to gain an understanding of educators supported in implementing the STEM innovation.

For that reason, the second part of survey section five involved asking educators if they felt support from their leaders, whether that be school leaders or district leaders based on job title. Additionally, both surveys asked respondents to provide details involving how leaders supported them through the implementation process. Additionally, the teacher survey asked respondents to consider other teachers and address if and how

they were supported by their fellow teachers. Furthermore, the leadership survey involved leaders addressing how they supported teachers' growth mindset through the implementation process. The four teacher survey items and the three leadership items addressing growth mindset provided the researcher with an understanding of growth mindset support in implementing the STEM innovation. Since both the teacher and leadership surveys differ, the following growth mindset examination focuses on teacher perspectives.

In examining the current supports of growth mindset, teachers were asked to examine if school leaders supported them through the process. If teachers acknowledged school leaders supported them through the process, they were asked to describe how school leaders supported them. In addition, teachers were also asked to examine if fellow teachers supported them through the implementation of STEM. Similarly, if teachers acknowledged fellow teachers supported them through the process, they were asked to describe how fellow teachers supported them through the process. Since teachers were required to provide descriptions of this support, an explanatory schema was utilized based on common descriptions. Table 59 provides common identified codes provided by teacher descriptions of how school leaders supported them through the implementation process.

Table 59

Teacher Descriptions Involving School Leader Support Through Implementation

Descriptions of School Leader Support	Coded Variable
School leaders allowed for the slow implementation of the innovation; school leaders allowed teachers to more slowly through the process	Slow Implementation
School leaders a limited number of lessons teachers were required to administer, school leaders only required one STEM lesson in the beginning	Limited Number of Lessons
School leaders provided resources such as materials, professional development, planning time, and lessons	Provided Resources
School leaders provided encouragement to explore STEM education on our own; they encouraged teachers to change their mindset of instructional practices	Provided Encouragement
School leaders implemented STEM goal teams to represent teachers; school leaders provided STEM discussions during Professional Learning Community agendas	STEM Teams
Showed us they are learning too, come in classroom and part of the activities, co-teaching, school STEM accreditation, social media celebrations, open to ideas, trust, letting staff learn through trial and error, attended training with teachers, aligned standards, Engineering Design Process and how it can apply to everything taught in the classroom, explaining what implementation looks like, and some teachers have received PD	Other

Table 59 provides teacher respondent descriptions involving school leader support shown during the implementation process. Teacher respondents provided numerous descriptions involving support provided by school leaders. Based on these descriptions, six themes were created. The theme of slow implementation was utilized to explain a slower implementation process. Additionally, the theme of limited number of lessons was utilized to explain the limited number of required STEM lessons during the implementation phase of the innovation. Also, the theme of provided resources was used to explain resources provided to teachers during the implementation process. Furthermore, the theme of provided encouragement was applied to responses explaining encouragement, and the theme of STEM teams was applied to explain the creation of

STEM goal teams and STEM discussions during professional learning communities. A sixth theme of “other” was created to explain uncommon themes found in teacher descriptions of how school leaders supported them through the implementation process.

As previously discussed, teachers were also asked to provide descriptions of how fellow teachers supported them through the implementation process. Since teachers were required to provide descriptions of this support, an explanatory schema was utilized based on common descriptions. Table 60 provides common identified codes provided by teacher descriptions of how fellow teachers supported them through the implementation process.

Table 60

Teacher Descriptions Involving Teacher Support Through the Implementation Process

Descriptions of Teacher Support	Coded Variable
Other teachers shared created or purchased lessons. Other teachers shared materials.	Sharing of Resources
Other teachers collaborated on lessons; teachers work together, teachers share ideas, teachers co-teach lessons, able to talk freely about challenges and successes	Collaboration
Providing encouragement	Encouragement
Teachers learning the innovation alongside each other	Learning Together
Everyone on board, teachers applied for grants, noticing of displays produced, and addressing others’ strengths	Other

Table 60 shows teacher respondents’ descriptions involving how fellow teachers supported them through the implementation process. Teacher respondents provided similar descriptions involving how they were supported by fellow teachers during the implementation of the STEM innovation. Based on these limited descriptions, five themes were created. The theme sharing of resources was applied to descriptions

explaining fellow teachers sharing lessons or materials. Additionally, the theme of collaboration was used to describe fellow teachers working together to create lessons, sharing ideas, co-teaching, or being able to discuss challenges and successes in implementing the innovation. The third theme of encouragement was created to describe fellow teachers providing one another with encouragement in implementing the innovation. Furthermore, a fourth descriptor of learning together was applied to all descriptions involving teachers learning the innovation alongside one another; however, some teacher descriptions, involving how their fellow teachers supported them through the implementation process, involve uncommon descriptors. Therefore, the theme of “other” was applied to these descriptions. Additionally, a respondent’s description could include numerous descriptions involving how fellow teachers supported them through the implementation process; therefore, some teacher respondent descriptions involved more than one coded variable. Figure 31 displays teacher responses focusing on current supports received involving the growth mindset.

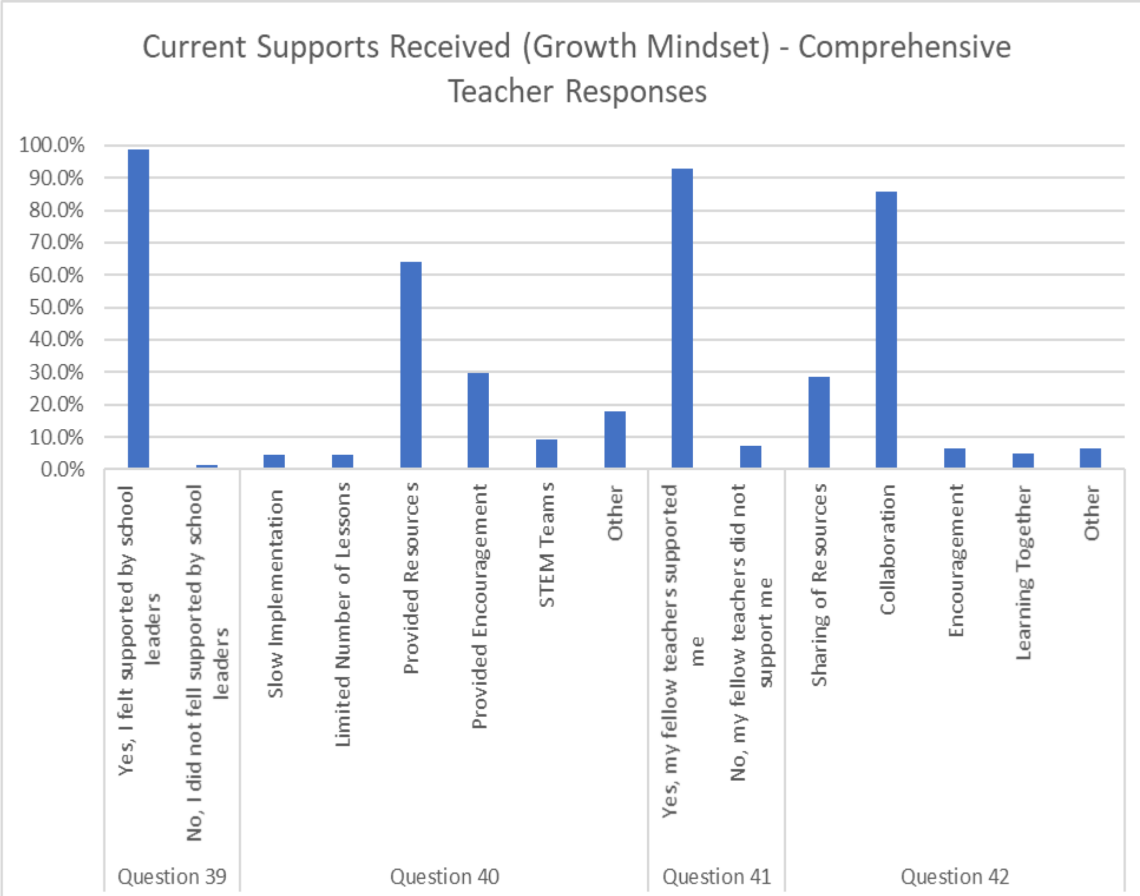


Figure 31. Teacher Responses: Current Supports Received in Growth Mindset. This figure presents a comprehensive understanding of teacher perspectives involving current growth mindset involved in implementing the STEM innovation.

As shown in Figure 31, four questions from the teacher survey focusing on the current supports received involving growth mindset were explored and analyzed. Quantitative data analysis revealed almost all teacher respondents felt supported by school leaders. When teachers were asked how leaders supported them through the process, the majority of respondents described leaders provided them with STEM resources. Also, 29.9% of teachers replied leaders provided them encouragement. Additionally, teachers were asked to examine if their fellow teachers supported them through the process. Quantitative data analysis revealed the majority of teachers

responded yes, their fellow teachers supported them through the implementation process. When asked how fellow teachers supported them through the process, the majority of teachers replied fellow teachers collaborated with them in differing ways. Also, 28.6% mentioned some teachers shared STEM resources.

As previously mentioned, school leaders were also asked to respond to survey questions involving the growth mindset; however, school leaders were asked three questions in section five of the leadership survey about encouraging the growth mindset. Specifically, school leaders were asked if and how they were supported by district leaders. An additional third question asked leadership respondents to describe how school leaders supported teachers' growth mindsets through the implementation process. Since school leaders were asked to describe how district leaders supported them through the implementation process, the question was presented in an open-ended format; therefore, the coded variables needed to be applied to each response. Table 61 provides descriptions school leaders offered as well as coded variables for each description.

Table 61

Leadership Descriptions Involving District Support Through Implementation

Descriptions of District Support	Coded Variable
Supportive with encouraging words, provided encouragement	Encouragement
District leaders kept the school in mind when STEM opportunities come available, provided school updates	STEM Learning Opportunities
Branding of school, resources, and funding	Other

Table 61 provides descriptions school leaders expressed involving district support received through the implementation process. The six school leader respondents provided descriptions leading to three coded variables. Multiple respondents provided the

two common themes of encouragement and STEM learning opportunities. Nonetheless, the category of “other” was also utilized for responses not identified with the theme of encouragement or STEM learning opportunities. Also, school leaders were asked to describe how school leaders supported teachers’ growth mindsets through the implementation process. Since school leaders were asked to describe how school leaders supported teachers’ growth mindset through the implementation process, coded variables needed to be applied to each response. Table 62 provides descriptions school leaders offered as well as coded variables for each description.

Table 62

Leadership Descriptions Involving Supporting Teachers’ Growth Mindset

Descriptions of Teachers’ Growth Mindset Support	Coded Variable
Enthusiasm and encouragement	Encouragement
Professional development	Professional Development
Support, school-wide focus, the roll-out of expectations, accountability, buy-in motivation, and support working with a partner to implement lessons	Other

Table 62 provides descriptions school leaders provided involving how school leaders supported teachers’ growth mindset through the implementation process of the STEM innovation. The school leader respondents provided descriptions leading to three coded variables; however, two common themes were identified. The two common themes of encouragement and professional development were provided by multiple respondents. Furthermore, the category of “other” was also utilized for responses not identified with these two themes. Figure 32 displays results from the leadership survey focusing on current supports received involving the growth mindset.

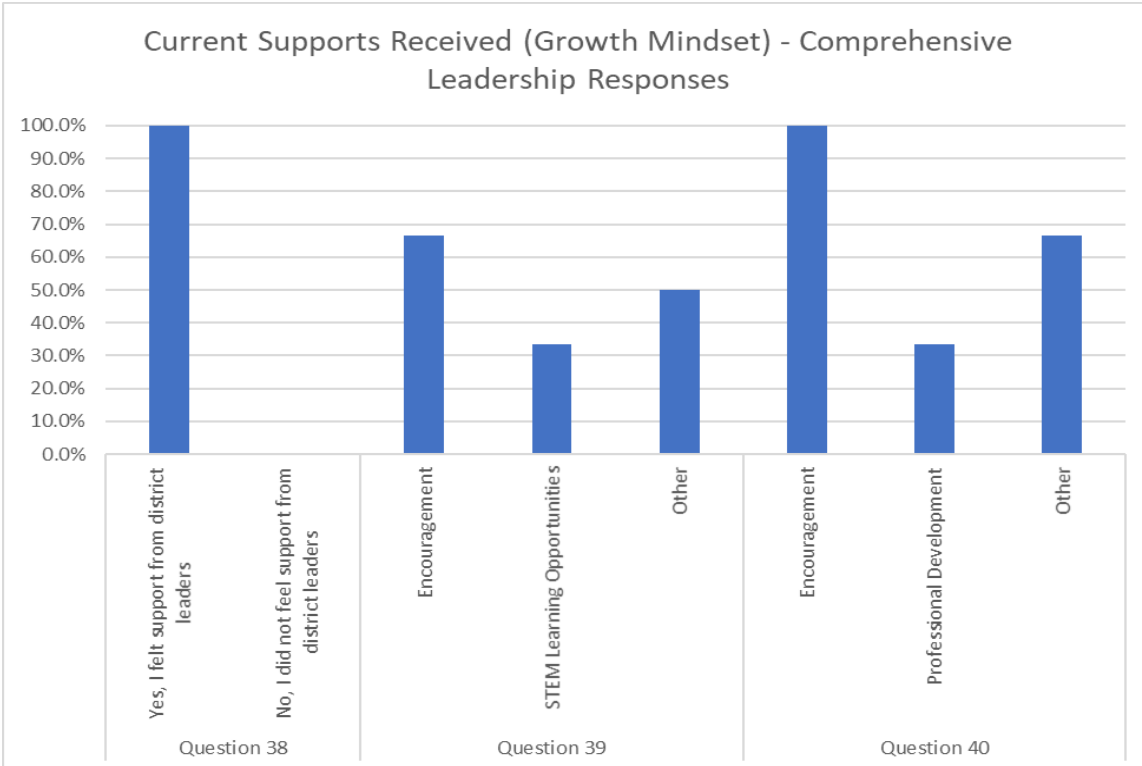


Figure 32. Leadership Responses: Current Supports Received in Growth Mindset. This figure presents a comprehensive understanding of school leaders' perspectives involving current growth mindset involved in implementing the STEM innovation.

As shown in Figure 32, three questions from the leadership survey focusing on the current supports received involving growth mindset were explored and analyzed. Quantitative data analysis revealed all six leadership respondents replied they received support from district leaders through the implementation process. Also, respondents provided a difference in opinions concerning how district leaders supported them through the implementation process, though the majority of respondents described district leaders provided them with encouragement. In addition, question 40 examined leadership perspectives involving how school leaders supported teachers' growth mindsets through the implementation process. Quantitative data analysis revealed the majority of leaders supported teachers by providing them with encouragement.

Resources. In addition to educators examining current supports encouraging mindset growth, teachers and leaders examined the support of resources. These questions were rooted in the understanding that support in the form of resources (i.e., materials, professional development, funds) are needed to support or enhance the quality of implementation. Particularly, Hall and Hord (2015) noted, "Change is one of the few constants in our world" (p. viii). With this idea in mind, educators understand educational policy or personal decisions can impact classroom instructional practices, and each change in idea signifies an opportunity to acquire new understanding. Support for this new understanding can be found internally and externally. Organizational change theory dictates support for change must be supplemented by a certain amount of influence, even when implementors are dedicated to the innovation (Fullan, 2002; Glickman et al., 2018; Hussain et al., 2016). If school leadership or district leaders are unable to sustain their dedication to and influence of the implementation of the innovation, engagement, and support will likely cease (Hall & Hord, 2015).

As mentioned previously, change is a team effort; therefore, no school implements an innovation alone. There are support systems that can be put into place to encourage the success of an innovation. Policies and mandates encourage innovation adoption, but it is the individual who determines if the implementation will occur or not in their classroom. These support systems create opportunities to drive the innovation forward.

Support for the innovation provides opportunities for educators to implement an innovation; however, supports can differ depending on demographics. Each school involved in the study expressed a different population of students. Therefore, support for

the innovation differed among the three schools. The following deals with resources needed in implementing STEM innovation.

To answer items involving current supports (resources) of the innovation, teachers were asked three questions. Each of the questions allowed teachers to express their perspectives concerning if they have sufficient access to STEM resources, from where did they obtain the materials needed to educate students in using the STEM innovation, and what resources has the school provided to make STEM innovation successful in the classroom. Additionally, school leaders were asked two questions to gain their perspectives of current resource support of the innovation. Similar to the teacher survey, the leadership survey asked respondents to provide if they believe teachers have sufficient access to STEM resources and what resources has the school provided to make STEM innovation successful in teachers' classrooms.

Figure 33 displays data concerning the perspectives of both teachers and school leaders involving sufficient access to STEM resources.

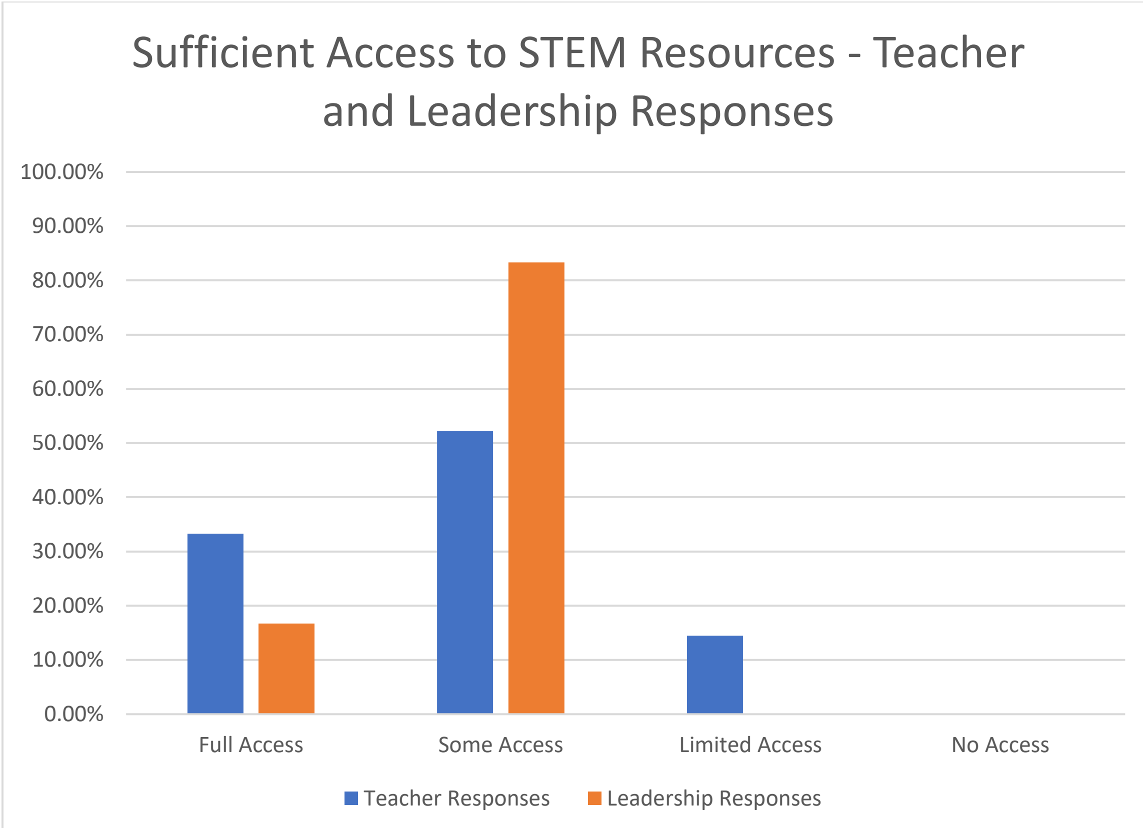


Figure 33. Teacher and Leadership Responses: Sufficient Access to STEM Resources. This figure compares teacher and leadership perspectives concerning sufficient access to STEM Resources.

Figure 33 presents data involving both teacher and leadership perspectives concerning sufficient access to STEM resources. Quantitative data analysis revealed the majority of teachers responded they have some access to STEM resources. Similarly, school leaders replied they believe teachers have some access to STEM resources. A few teachers (33.3%) and leadership (16.7%) respondents provided teachers have full access to STEM resources, and a small number of teacher respondents responded they have limited access to STEM resources; however, no respondents, teachers or leadership, responded they have no access.

In addition to educators providing their opinion concerning sufficient access to

STEM resources, teachers examined from where they obtained materials needed to educate students in using STEM innovation. Figure 34 displays teacher responses for this item.

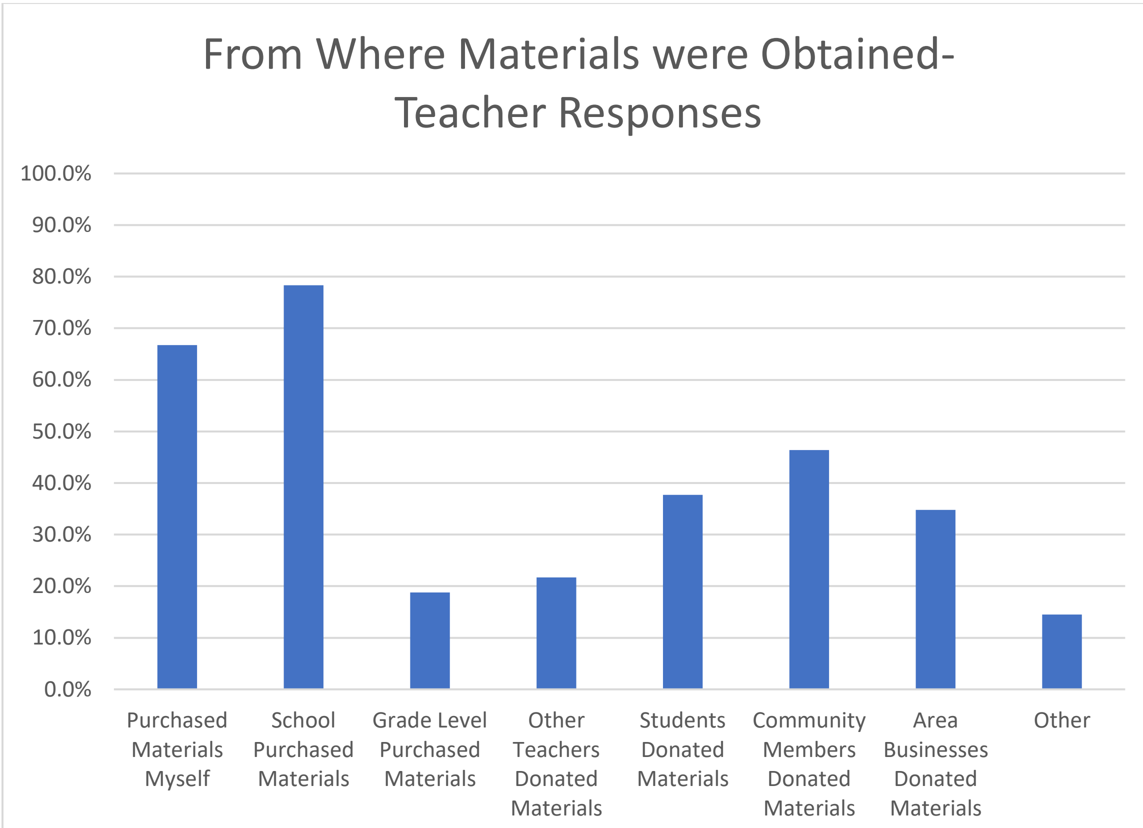


Figure 34. Teacher Responses: From Where Materials were Obtained. This figure displays the percent of cases involving from where materials were obtained to educate students in using the STEM innovation.

Figure 34 shows the percent of cases involving teacher respondent data concerning from where materials were obtained to educate students in using STEM innovation. Quantitative data analysis revealed the majority of teachers replied the school purchased the materials needed to educate students in using the STEM innovation, though more than half of teachers also responded they purchased materials themselves to help educate students. A few respondents replied either community members (46.4%),

area businesses (34.8%), or students (37.7%) donated the needed materials. Additionally, some teacher respondents replied the materials needed to educate students in using STEM innovation were obtained from "other" locations. Table 63 describes the other locations where materials were obtained.

Table 63

Teacher Description of where Materials were Obtained "Other" Category

Heritage Elementary "Other" Descriptions	Old Mountain Elementary "Other" Descriptions	Louis Armstrong Elementary "Other" Descriptions
Borrowed materials, fundraiser funds, small grant, and Donors Choose	Grants, church donations and Pinterest	Bookfairs (money not needed for collection development) and grants

Table 63 shows "other" descriptions regarding where teachers obtained materials needed to educate students in using STEM innovation. Data reveal each school provided descriptors leading to the classification of "other." All three schools provided teacher respondents who responded materials were obtained from grants. Also, one respondent responded materials were obtained through Pinterest; however, this reply described how ideas were obtained and not necessarily how materials were obtained.

In addition to teachers examining where materials were obtained to educate students in using STEM innovation, teachers and leaders were asked to examine what resources the school provided to make the STEM innovation successful in the classroom. Figure 35 displays teacher and leadership responses for this item.

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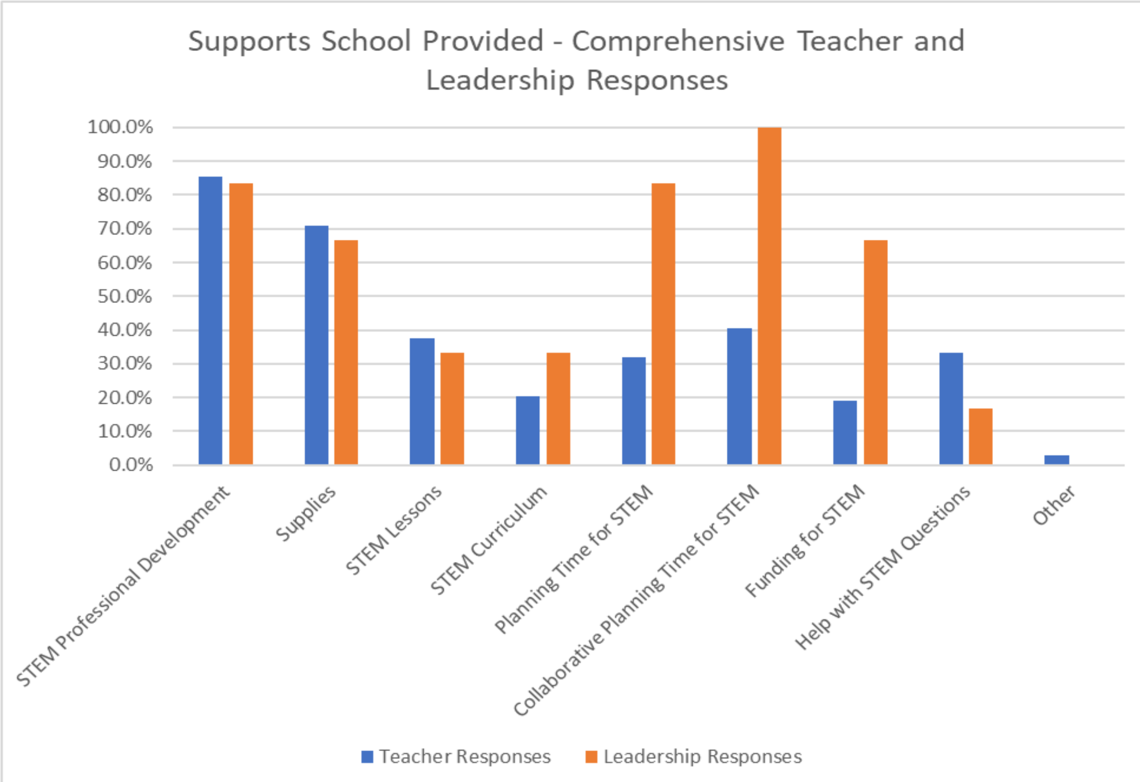

Figure 35. Teacher and Leadership Responses: Resources Schools Provided for Classroom Success. This figure displays and compares teacher and leadership responses involving supports the school provided to make the STEM innovation successful in the elementary classroom.

Figure 35 shows teacher and leadership responses addressing what resources the school provided to make the STEM innovation successful in the classroom. Quantitative data analysis revealed the majority of teacher respondents responded the school provided STEM professional development as a support in encouraging successful implementation of STEM innovation in the elementary classroom. Similarly, 83.3% of leadership respondents responded with this support was provided. Also, a difference between teacher and leadership perspectives are seen in the area of planning and collaborative planning time for STEM as well as funding. The majority of leaders replied the school provided teachers with collaborative planning time or planning time for STEM; however,

teachers are not in agreement with this pronouncement. Less than half of teacher respondents agreed with this leadership statement. Also, more than half of the leadership respondents responded the school provided funding for STEM; however, less than 20% of teacher respondents agreed with this statement. In addition, two teacher respondents indicated additional resources the school provided to make the STEM innovation successful in the classroom. These two respondents stated the school provided a STEM focused team consisting of staff members for the school; and while the school did provide funds used in a STEM lesson provided for a certain occasion, all other STEM lesson resources have been provided by the teacher.

Professional learning. In addition to educators examining current resources for the innovation, teachers and leaders also examined professional learning supports received. These questions involving professional learning were rooted in the understanding that additional learning is needed to gain an understanding of STEM education as well as providing ways to transition instructional practices. As previously mentioned, STEM innovation is becoming a routine in the elementary setting; however, how the educator comprehends, conceptualizes, and interconnects the content of the innovation influences the learning capabilities of students (Diefes-Dux, 2014; Estapa & Tank, 2017). Ejiwale (2013) wrote, “There is growing concern that the United States is not preparing a sufficient number of students, teachers, and professionals in the areas of science, technology, engineering, and mathematics” (p. 64); therefore, professional learning opportunities are needed to prepare educators in these areas. For this reason, educators who have fewer experiences with the innovation may struggle with implementation (Boyle et al., 2013).

Support of professional learning (referred to professional development in the educator surveys) provides educators with an opportunity to learn and improve in their practice (Western Governors University, 2017). Additionally, Hall and Hord (2015) pointed out that professional learning is a significant piece of the process needed for the implementation of the innovation to become successful. Through these professional learning opportunities, educators shape their understanding of STEM content and construct a “culture of STEM education at the school” (Office of Innovation and Improvement, n.d., para. 5); however, a school’s support of professional learning opportunities differs depending on funding and other supports available to the school. Therefore, each school involved in the study expressed different professional learning opportunities. To aid in the understanding of to what extent elementary educators are supported in their implementation of the STEM innovation, survey questions involving professional learning opportunities were utilized.

To answer items involving professional learning opportunities needed in implementing STEM innovation, teachers were asked two professional learning questions. One question involved teacher respondents describing the number of school-offered professional development sessions attended as well as answering what STEM professional development opportunities were received. Figure 36 displays data involving teacher perspectives relating to the teacher survey’s two professional development items.

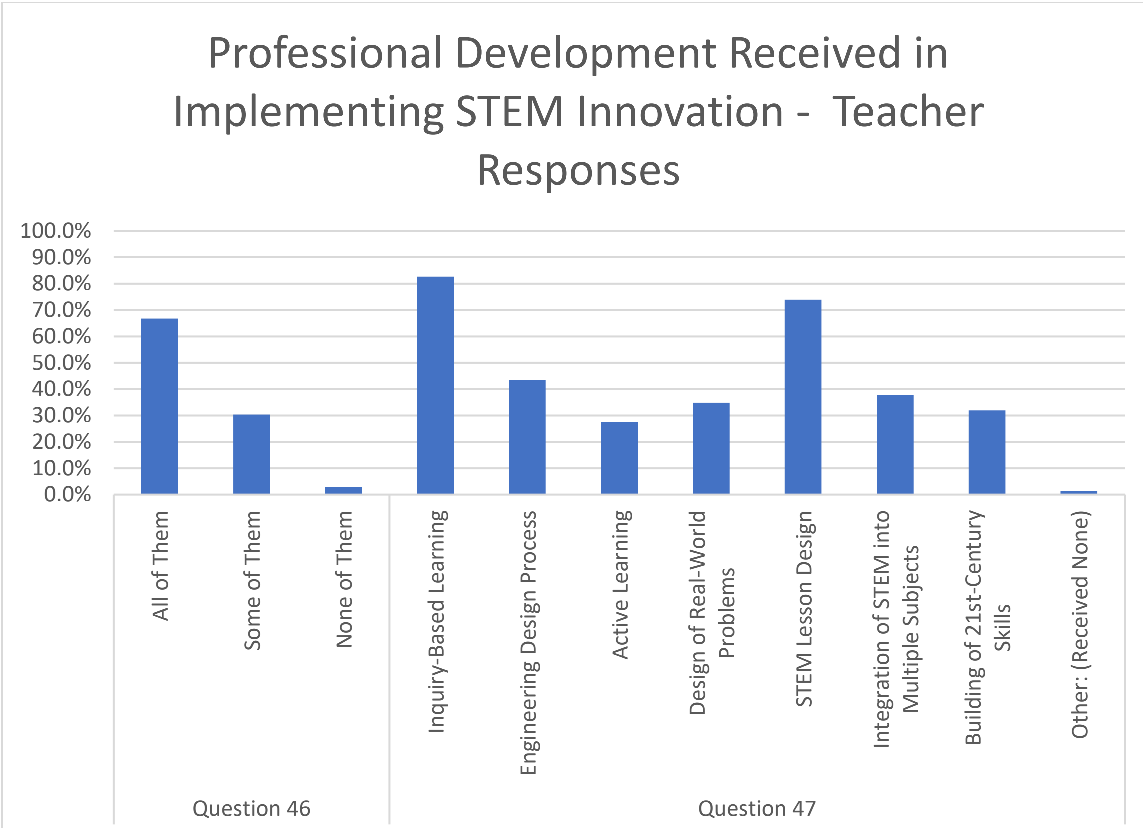

Figure 36. Teacher Responses: STEM Professional Development Received. This figure displays teacher responses involving the number of attended STEM professional development sessions and specific STEM professional development opportunities.

Figure 36 shows teacher perspective data involving professional development received in implementing STEM innovation. Quantitative data analysis revealed while the 66.7% of teachers have received STEM professional development (question 46), not all teachers have received STEM professional learning experiences. Also, those who have received STEM professional learning have received professional learning opportunities centered around inquiry-based learning and STEM lesson design. While these elements encourage growth with the innovation, they do not support educators in transitioning traditional instructional practices to practices supporting integrated interdisciplinary learning practices that STEM requires.

Additionally, school leaders were asked four professional development questions

to gain their perspectives involving to what extent elementary educators were supported through professional learning opportunities. The first question invited school leaders to describe how many professional development sessions each school held during the 2017-2018 school year. Additionally, school leaders were asked of those professional development sessions, how many of them involved the STEM innovation. Furthermore, to gain an understanding of their participation in these sessions, school leaders were asked how many professional development sessions involving STEM did they attend as a school leader. The fourth question addressed school leader perspectives involving professional learning and asked respondents to describe the STEM professional learning opportunities they received. To gain a numerical understanding, three tables were utilized. Figure 64 provides frequency data involving numerical responses connecting the number of presented professional development sessions each of the three elementary schools offered during the 2017-2018 school year.

Table 64

Leadership Descriptions: Number of School Offered Professional Development Sessions

Number of Professional Development Sessions During the 2017-2018 School Year	Heritage Elementary			Old Mountain Elementary			Louis Armstrong Elementary		
	Responses		%	Responses		%	Responses		%
	#	%	of Cases	#	%	of Cases	#	%	of Cases
Two	0	0.0%	0.0%	1	50.0%	50.0%	0	0.0%	0.0%
Four	0	0.0%	0.0%	0	0.0%	0.0%	1	50.0%	50.0%
Seven	2	100.0%	100.0%	0	0.0%	0.0%	0	0.0%	0.0%
Other	0	0.0%	0.0%	1	50.0%	50.0%	1	50.0%	50.0%
Total	2	100.0%	100.0%	2	100.0%	100.0%	2	100.0%	100.0%

Figure 64 presents quantitative frequency data describing the number of professional development sessions each school offered during the 2017-2018 school year.

Respondents were asked to provide the number of offered professional development sessions during the 2017-2018 school year. Many respondents provided numerical data for this item; however, two respondents' responses were labeled as "other." Explanation of the two responses labeled as "other" follows the description of Figure 83.

Quantitative data analysis revealed two schools expressed inconsistent data between the two leadership respondents; however, comparable data are found at Heritage Elementary. Both respondents replied there were seven professional development sessions offered during the 2017-2018 school year. At Old Mountain Elementary, two leadership respondents differed concerning the number of professional development sessions the school offered during the 2017-2018 school year. One respondent replied the school had two professional development sessions; however, this respondent revealed they started their position in January 2018. Additionally, the second respondent's numerical response gained the label "other." This respondent provided details involving STEM professional development sessions instead of the number of all professional development sessions; therefore, the label of "other" was placed on the response. Quantitative data analysis revealed inconsistent data between the two leadership respondents at Louis Armstrong Elementary. Data revealed one respondent responded the school offered four professional development sessions during the 2017-2018 school year; however, the other respondent's reply was labeled "other." This respondent provided a range instead of a precise number. Table 65 provides responses described as "other."

Table 65

Leadership Descriptions of "Other" Involving Professional Development Sessions

Harmony Elementary	Old Mountain Elementary	Louis Armstrong
No "other" responses identified	Teachers meet bi-weekly to discuss STEM goal team deployment steps. Six Professional STEM expert training. Ongoing coaching support in post conferences.	18-20

Table 65 shows leadership respondents' descriptions of "other" involving the number of professional development sessions each school offered during the 2017-2018 school year. As previously mentioned, item 43 of the leadership survey asks respondents to provide a numerical response describing the total number of all professional development sessions offered; however, two respondents provided responses not identified through a common variable. Therefore, these responses were labeled "other." Instead of providing a numerical response describing the number of professional development sessions, one leadership respondent expressed information concerning the STEM innovation. The respondent mentioned teachers would meet twice a week to discuss STEM goal team deployment steps. In addition, the respondent also described the number of offered STEM professional development sessions as well as ongoing support. The final respondent provided a range in the number of sessions instead of a precise number.

In addition to respondents providing the number of professional development sessions each school offered during the 2017-2018 school year, leadership respondents were also asked to provide a numerical response describing the number of offered STEM professional development sessions. Table 66 provides frequency data describing the number of offered STEM sessions.

Table 66

Leadership Responses: Number of School Offered STEM PD Sessions

Number of STEM Professional Development Sessions During the 2017-2018 School Year	Heritage Elementary			Old Mountain Elementary			Louis Armstrong Elementary		
	Responses		% of Cases	Responses		% of Cases	Responses		% of Cases
	#	%		#	%		#	%	
Two	0	0.0%	0.0%	1	50.0%	50.0%	0	0.0%	0.0%
Four	0	0.0%	0.0%	0	0.0%	0.0%	1	50.0%	50.0%
Five	2	100.0%	100.0%	0	0.0%	0.0%	0	0.0%	0.0%
Six	0	0.0%	0.0%	1	50.0%	50.0%	0	0.0%	0.0%
Eight	0	0.0%	0.0%	0	0.0%	0.0%	1	50.0%	50.0%
Total	2	100.0%	100.0%	2	100.0%	100.0%	2	100.0%	100.0%

Figure 66 presents quantitative frequency data describing the number of STEM professional development sessions each school offered during the 2017-2018 school year. Respondents were asked to describe the number of offered STEM professional development sessions during the 2017-2018 school year. Each school described offering STEM professional development sessions; however, each school differed in the number of sessions. Also, inconsistencies can be seen between the two leaders at two of the elementary schools, though one school did provide compatible data.

Additionally, leadership respondents were also asked to provide the number of STEM professional development sessions they attended as a school leader. Mizell (2010) mentioned professional development is effective when it instigates leadership into becoming better leaders for the school. As previously mentioned, each of the three schools chose to become schools dedicated to STEM innovation; therefore, all educators needed to understand the innovation to successfully implement the design. One way to understand the innovation and the change in mindset required is through professional

development opportunities; therefore, Table 67 provides the number of STEM professional development sessions each leadership respondent attended as a school leader.

Table 67

Leadership Responses: Number of STEM Professional Development Sessions Attended

Number of STEM Professional Development Sessions Attended	Heritage Elementary			Old Mountain Elementary			Louis Armstrong Elementary		
	Responses		%	Responses		%	Responses		%
	#	%	of Cases	#	%	of Cases	#	%	of Cases
Zero	0	0.0%	0.0%	1	50.0%	50.0%	0	0.0%	0.0%
Four	0	0.0%	0.0%	0	0.0%	0.0%	1	50.0%	50.0%
Five	2	100.0%	100.0%	1	50.0%	50.0%	0	0.0%	0.0%
Eight	0	0.0%	0.0%	0	0.0%	0.0%	1	50.0%	50.0%
Total	2	100.0%	100.0%	2	100.0%	100.0%	2	100.0%	100.0%

Heritage Elementary is the only school in which both leadership respondents acknowledged attending the same number of STEM professional development sessions. Both respondents disclosed they attended five STEM professional development sessions. In addition, Old Mountain Elementary leadership respondents differed in the number of STEM sessions they attended as a school leader. One respondent acknowledged they attended no STEM professional development sessions. Additionally, the other leadership respondent mentioned they attended five STEM sessions. Furthermore, Louis Armstrong Elementary leadership respondents also differed in the number of STEM sessions attended. One respondent described attending four STEM professional development sessions, while the other leadership respondent attended eight STEM sessions.

Additionally, leadership respondents were also asked to indicate STEM professional learning opportunities received. Lambert (2003) wrote most often

professional learning opportunities are thought to be teacher oriented; however, professional learning is meant to be collaborative, reflective, and engaging opportunities that provide learning for all educators (Lambert, 2003). Therefore, to gain an understanding of how school leaders are supported in their implementation of the STEM innovation, the researcher wanted to gain perspectives of these educators about professional learning opportunities received. Figure 37 shows leadership perspectives concerning this item.

Figure 37. Leadership Responses: STEM Professional Development Received. This figure displays school leaders' responses involving current supports received (professional development).

Figure 37 shows leadership response data involving STEM professional development opportunities school leaders received. Quantitative data analysis revealed the majority of school leaders replied they received professional development involving

the design of real-world problems; however, 66.7% of school leaders responded to receiving professional development about STEM lesson design. Likewise, 66.7% of school leaders replied they received professional development involving the building of 21st century skills. Also, only half of the respondents responded they received professional development opportunities involving inquiry-based learning, EDP, active learning, or the integration of STEM into multiple subjects.

Focus group data. Focus group sessions were conducted at each of the three elementary schools involved in the study to gain an understanding of the current supports received in implementing the STEM innovation. The teachers participating in their group session were able to voice their perspectives freely. In addition, leadership members met at a central location and were able to participate in their focus group session. All four focus group sessions involved one item focusing on current supports received. All sessions enabled the researcher to gain an understanding of to what extent elementary educators are supported in their implementation of the STEM innovation which addressed Research Question 4. The question used to examine this perspective differed based on the position of those participating in each session.

The teacher focus group question supporting Research Question 4 asked teachers to described supports received that encouraged them to transition traditional practices to ones that support STEM education. This question was rooted in the understanding that supports are needed from different locations for teachers to transition practices to ones supporting STEM. Likewise, leaders were asked to describe supports the school received that encouraged teachers to transition instructional practices to ones that support STEM education. Table 68 displays a quantitative breakdown of both the teacher and leadership

focus group sessions.

Table 68

Quantitative Breakdown Focus Group Responses–Supports Received

Coded Theme	Referenced by Teachers	Referenced by Leadership	Total
Grants	6	6	12
Partnerships (Parent, Community, and Cooperation)	7	7	14
Professional Development	12	1	13
Materials	3	0	3
PTO Support	1	1	2
Aligned Science Standards	2	0	2
Provided Planning Time	2	0	2
Other	7 (STEM teacher, STEM Teams, Makerspaces, Greenhouse, Personalized STEM Design for School)	3 (After School Clubs, Teacher Leaders, Social Media)	10

Table 68 reveals a quantitative breakdown of the teacher and leadership focus group item focusing on supports received. In analyzing the focus group data, eight themes emerged focusing on supports received that encouraged transitioning of traditional practices to ones that support STEM education. Some specific quotes supporting these supports are explored in Table 69.

Table 69

Focus Group Responses–Perspectives Describing Supports

Coded Theme	Supporting Quotes
Grants	"We got several grants."
	"We got a fifty-three-thousand-dollar grant to help purchase materials and create STEM spaces around the school."
Partnerships (School, Parent, Community, and Cooperation)	"I would say for [Old Mountain Elementary], having [Louis Armstrong] start a year ahead of us. We got to see what they were doing and learned a lot."
	"We met with other schools that were implementing STEM."
Professional Development	"I would say first and last we started off having the district help provide us with a partnership with [professional learning education center]."
	"We were lucky to have a teacher to works for NC State over the summer doing STEM. So that has helped us with our professional development. We are working now with NCAT."
Materials	"We made a mobile cart that had materials on it."
PTO Support	"We got a lot of PTO support that helped us to purchase professional development."
Aligned Science Standards	"STEM team members realigned science standards over the summer to provide consistent science practice throughout the school."
Provided Planning Time	"Planning time has been provided on Early Release Day to encourage teachers to collaborate on STEM ideas."
Other	"I think it helps that we had an Odyssey of the Mind and we had a robotics team already."
	"Having a STEM position [teacher]."

Table 69 describes some specific quotes teachers and school leaders expressed describing supports received encouraging the transition from traditional instructional practices to ones supporting STEM education. Qualitative data analysis revealed participants described supports received with short descriptions. In particular, two schools mentioned receiving substantial financial support from grant backing. Through the received funds, the two schools were able to set up partnerships with STEM professional learning education centers, create STEM learning areas, and purchase

materials to help teachers implement STEM instructional practices. One school worked with the school's PTO to provide additional support. Even though one school involved in the research received no substantial funding from a grant, the school was able to provide a partnership with a STEM professional learning education center that provided select teachers STEM professional development opportunities. Additionally, the school realigned science standards to encourage a uniform science curriculum across the school. Also, the school provided a uniform STEM design that created consistent STEM vocabulary across the school (Leadership focus group participant, personal communication, November 29, 2018; Teacher focus group participant, personal communication, December 12, 2018).

Even though professional learning opportunities were the foundation of supporting teachers in transitioning from traditional instructional practices to practices supporting STEM, some of the professional learning experiences were met with frustration. Specifically, one teacher focus group participant (personal communication, November 30, 2018) stated, "We have gotten some professional development, but many times the professional development was not for elementary. We have been frustrated because it is a little higher education focused." Additionally, another participant mentioned not all professional development instructors had the same understanding of STEM instructional practices, which led to confusion when implementing the innovation in the classroom:

> It got frustrating because the trainers would say something different. So, all the training that we did was not necessarily consistent, and that causes much confusion, and it is not a matter of right and wrong. However, one would suggest

> you do this, this, and this, and then we would have some additional training, and the instructor would say no, I would not do that, I would do this instead. That is frustrating. (Teacher focus group participant, personal communication, November 30, 2018)

Many focus group participants described similar experiences, expressing that maybe having a common understanding of what constitutes STEM would support them in being able to change from traditional educational practices to practices that support STEM.

Further support of STEM innovation. Research Question 5, "How could the STEM innovation be further supported in the elementary classroom," was shaped to address how the four supports of STEM innovation (funding, growth mindset, resources, and professional learning) could further be supported now that the innovation has been implemented for multiple years in each of the schools involved in the study. Through this research question, the researcher acquired an understanding of how STEM education could further be supported. To gain this understanding, the researcher collected quantitative data from teacher and leadership surveys as well as qualitative data from teacher and leadership focus groups.

This question's importance in the study finds its roots in the development of building continuous support in encouraging permanent growth of educators' STEM understanding using the innovation. As previously identified in Research Question 4, success of STEM innovation depends on a shared vision of support. Research Question 5 extends this shared vision and allowed educators to examine and identify how support for the innovation could increase at the elementary level.

Survey data. As previously discussed, an educator survey was made available to

both teachers and school leaders for 3 weeks. Section six of both surveys described how the STEM innovation could be supported further in the elementary classroom. Both surveys' section six were divided into four parts, with each part focused on supports developed through the literature review; however, both surveys differed in that the different surveys addressed perspectives from teachers and leaders. Table 70 displays the alignment between the surveys and Research Question 5.

Table 70

Educator Survey Alignment to Research Question 5

Research Question 5 Component	Aligned Items in Teacher Survey	Aligned Items in Leadership Survey
Further Funding	48 (Dichotomous Response)	47 (Dichotomous Response)
Further Growth Mindset Support	49 and 50 (Dichotomous Response)	48 and 49 (Dichotomous Response)
Further Resources	51 (Multiple Response)	50 (Multiple Response)
Further Professional Development	52 (Multiple Response)	51 (Multiple Response)

Table 70 displays aligned questions found on both the teacher and leadership surveys. Each question was formed with continuous support for STEM innovation in mind. To support Research Question 5, five survey questions were developed and analyzed for the teacher survey. Likewise, five survey questions were also developed and analyzed for the leadership survey. Each question differed in format based on the type of feedback required.

The first part of survey section six examined teacher and leadership perspectives involving how STEM innovation could be further funded in the elementary classroom. Specifically, respondents examined one thing they could work towards to increase funding. Figure 38 shows teacher and leadership responses involving this focus.

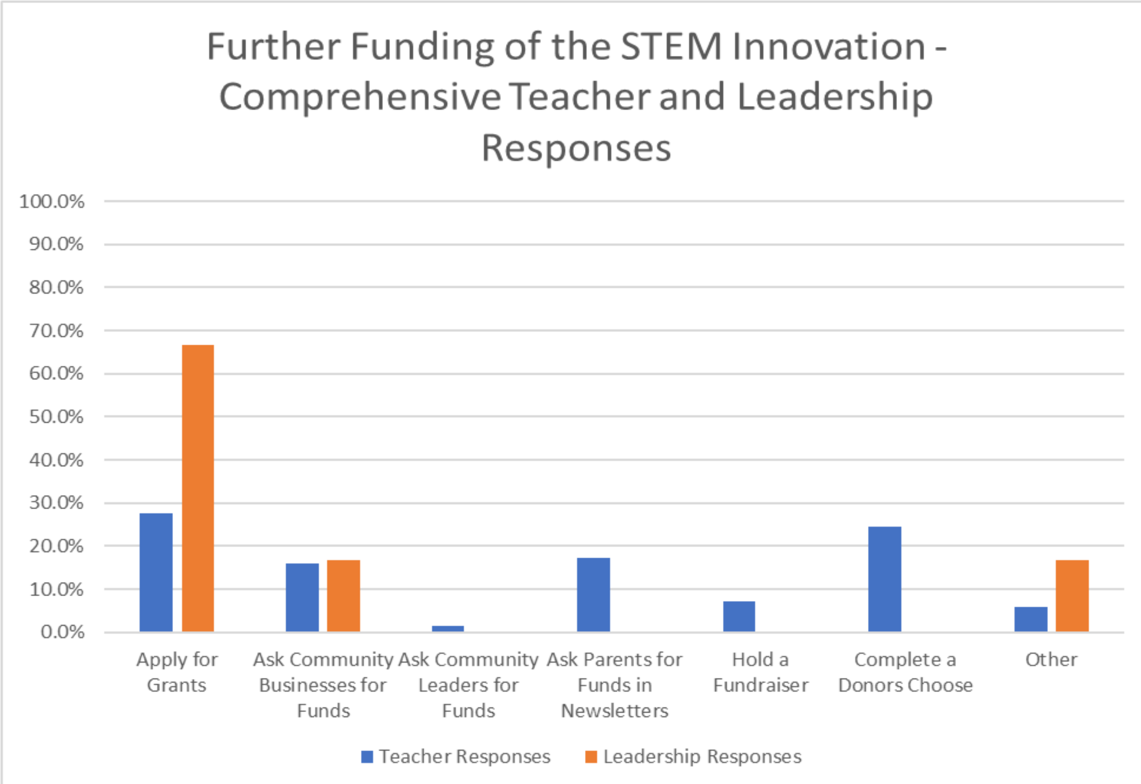

Figure 38. Teacher and Leadership Responses: Further Funding of STEM Innovation. This figure displays teacher and school leader responses involving what one thing they could work towards to increase funding for the STEM innovation is.

Figure 38 describes frequency data involving one thing educators could work towards to increase funding for STEM innovation. Data revealed the majority of teacher respondents responded they could work towards applying for either federal, state, or local grants. Likewise, leadership respondents revealed similar data in that the majority of respondents also described they could work towards applying for grants. Also, data analysis revealed leadership respondents limited their perspectives and considered grants or community partnerships as a targeted area for acquiring future funding for the innovation, though teachers were more willing to try different ways to acquire STEM funding for their classrooms.

In addition to educators examining how STEM could be further funded, teachers

and leaders also examined how the growth mindset could be further supported. Specifically, respondents examined one thing school leaders could do to support further mindset growth. Figure 39 describes both teacher and leadership perspectives for this item.

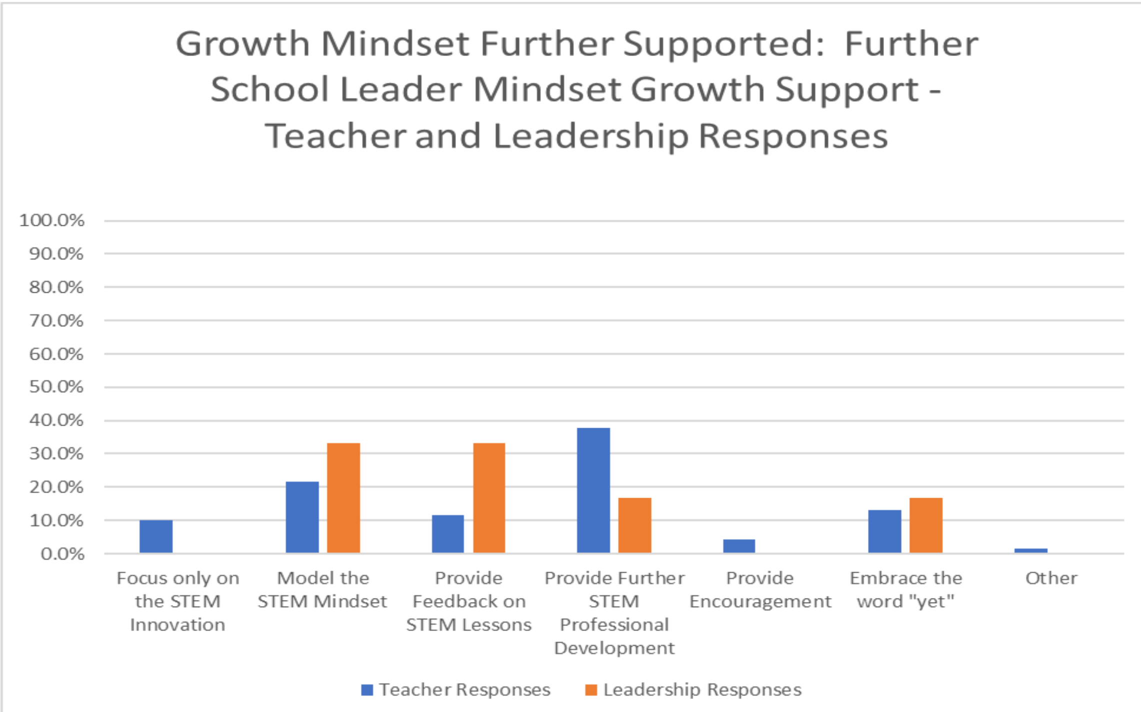

Figure 39. Teacher and Leadership Responses: Further School Leader Support of Mindset Growth. This figure displays comprehensive teacher and leadership response frequency data involving one thing school leaders could accomplish to support further mindset growth.

Figure 39 examines teacher and leadership responses involving one thing school leaders could do to support further mindset growth. Analyzed data revealed the majority of teacher respondents responded school leaders could provide further STEM professional development, though the majority of school leaders did not respond with this selection. Analyzed leadership data revealed the majority of leadership respondents responded school leaders could either model the STEM mindset or provide feedback on STEM lessons. Only, 21.7% of teacher respondents responded with this selection.

In addition to educators examining one thing school leaders could do to support further mindset growth, teachers and leaders examined one thing they could do to further support their own mindset growth. Figure 40 describes both teacher and leadership perspectives for this item.

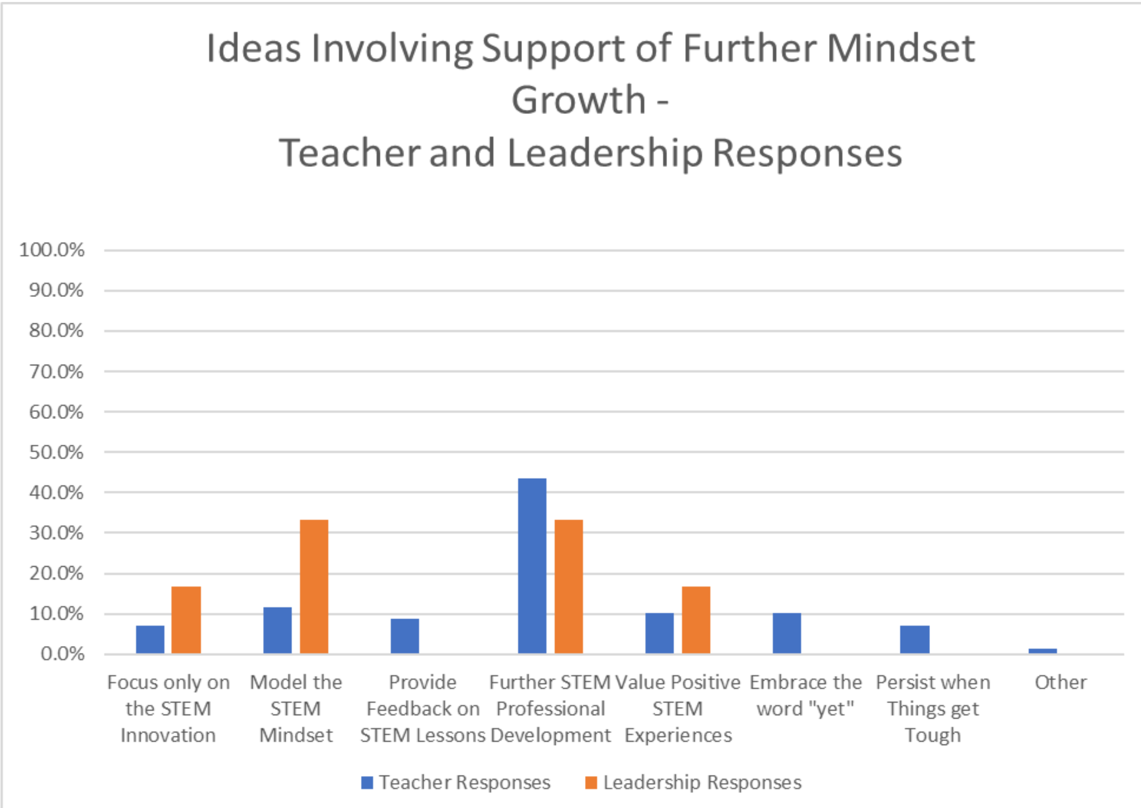

Figure 40. Teacher and Leadership Responses: Personal Support of Further Mindset Growth. This figure displays comprehensive teacher and leadership response frequency data involving one thing respondents could accomplish to support further mindset growth.

Figure 40 shows teacher and leadership responses involving one thing they could do to further support their own mindset growth. Quantitative analyzed data revealed the majority of teacher respondents responded attending further professional development could support further mindset growth, though the majority of leadership respondents were split in their perspectives. Leadership respondent data revealed 33.3% of respondents

responded modeling the STEM mindset could support their further mindset growth. Likewise, 33.3% of leadership respondents responded attending further STEM professional development could support further mindset growth.

In addition to educators examining how the growth mindset could be further supported, teachers and leaders also examined further resources needed to support future implementation of STEM innovation. Specifically, respondents described additional resources needed for further successful implementation of STEM innovation. Figure 41 describes both teacher and leadership perspectives for this item.

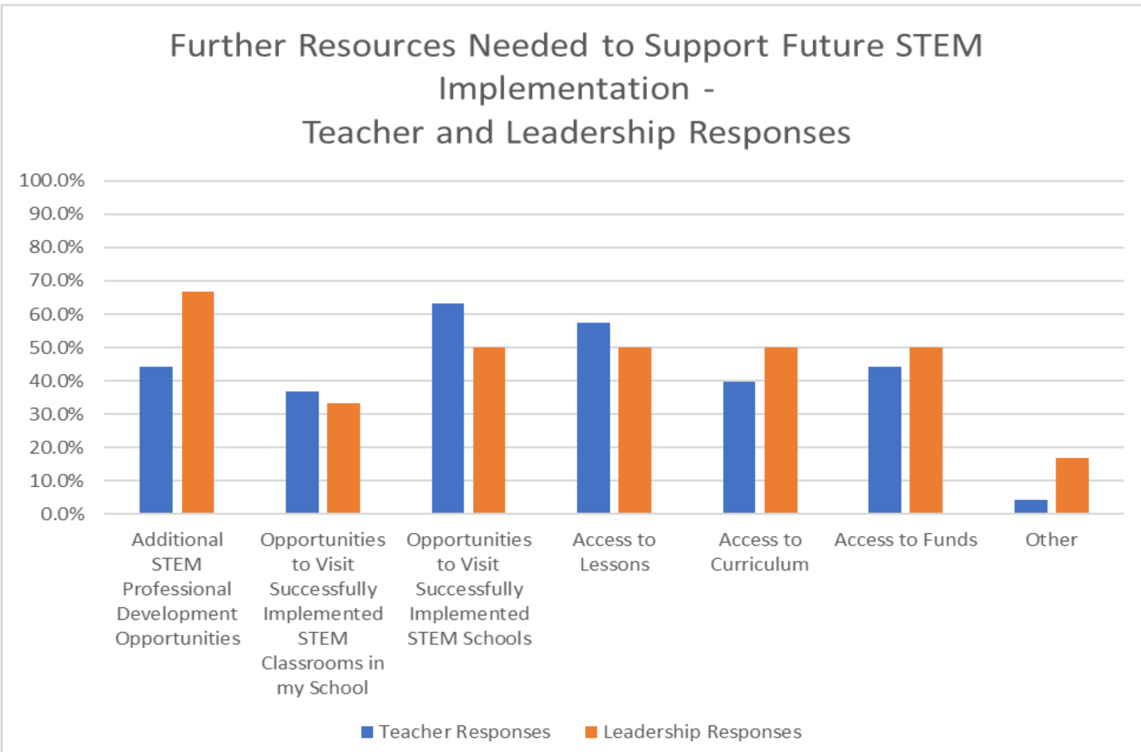

Figure 41. Teacher and Leadership Responses: Further Resource Support Needed. This figure displays comprehensive teacher and leadership response frequency data involving additional resources needed to support future implementation of the STEM innovation.

Figure 41 provides frequency data involving teacher and leadership perspectives on further resources needed for successful implementation of STEM innovation.

Analyzed data revealed teachers and leaders held similar views involving additional resources needed, though the majority of leaders responded additional STEM professional development opportunities are needed for further successful implementation and only 44.1% of teachers responded with this selection. For the majority of teachers, analyzed data revealed they would like opportunities to visit implemented STEM schools. Also, data revealed that in teachers' opinions, the four top further resources needed for successful STEM implementation were opportunities to visit implementation STEM schools, access to STEM lessons, additional STEM professional development, and access to funds. Leadership data revealed the five (four resources received the same number of replies) top further resources needed for successful STEM implementation were additional STEM professional development, opportunities to visit successfully implemented STEM schools, access to lessons, access to curriculum, and access to funds.

In addition to educators examining additional resources needed for further successful implementation of STEM innovation, teachers and leaders also examined further professional development experiences needed to support future implementation of STEM innovation. Specifically, respondents described professional development experiences that would help successfully implement STEM. Figure 42 describes both teacher and leadership perspectives for this item.

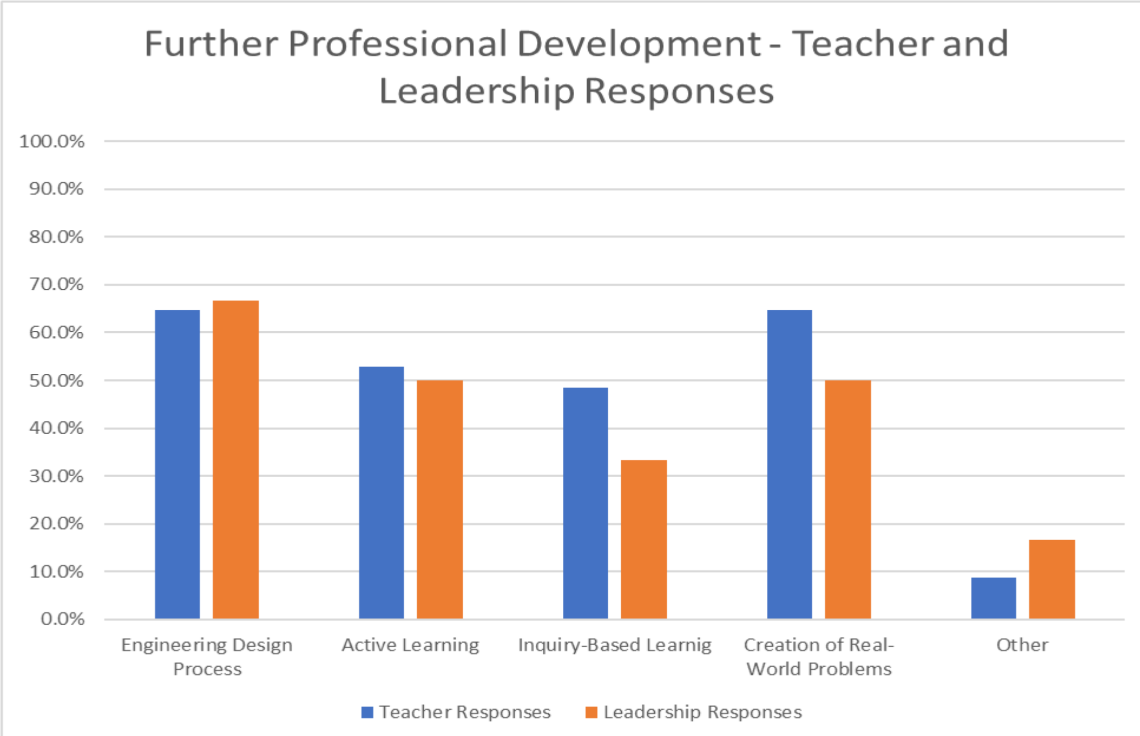

Figure 42. Teacher and Leadership Responses: Further STEM Professional Development Support Needed. This figure displays comprehensive teacher and leadership response frequency data involving further professional development needed to support the future implementation of the STEM innovation in the elementary classroom.

Figure 42 presents teacher and leadership frequency data involving further professional development needed in supporting STEM in the elementary classroom. Quantitative analyzed data revealed the majority of teacher respondents responded EDP professional development as well as the creation of real-world problems would help in successfully implementing STEM innovation. Leadership respondents supported the idea of EDP professional development is needed to encourage successful implementation of STEM, though leadership respondents responded professional development in active learning and the creation of real-world problems is equally as important.

Focus group data. All four focus group sessions involved questioning allowing for multiple perspectives to be observed, recorded, transcribed, and reviewed by the

researcher. Responses from focus group sessions relating to Research Question 5, "How could the STEM innovation be further supported in the elementary classroom," revolved around one focus group interview protocol question. This question was rooted in the understanding that support for innovation is continuous and was shaped to examine how STEM could be further support at the elementary level. Table 71 displays a quantitative breakdown of each focus group session for this focus group question.

Table 71

Quantitative Breakdown Focus Group Responses–Further STEM Support

Coded Theme	Referenced by Teachers	Referenced by Leadership	Total
Partnerships	2	3	6
STEM Accreditation	1	4	5
Further Funding	2	0	2
Visiting Other STEM Schools and Districts	3	0	3
Common STEM Understanding	7	0	7
Flexibility with District Support	0	2	2
Book study	2	0	2
Quality and Consistent Professional Learning	7	0	7
Other	6 (Access to Curriculum, Lessons Designed for Younger Students, Time to Refine, Connecting STEM to Careers, Allow Teachers to Try Something New, Smaller Class Size)	0	6

Table 71 displays the quantitative breakdown of focus group responses focusing on how STEM could further be supported in the elementary classroom. In analyzing

focus group data, nine themes emerged. These themes were partnerships, STEM accreditation, further funding, visiting other STEM schools and districts, common STEM understanding, flexibility with district support, book study, quality and consistent professional learning, and other. Data analysis revealed the top discussed actions for how STEM could be further supported were found in partnerships, STEM accreditation, common STEM understanding, and quality and consistent professional learning. Some specific quotes supporting each of the top further supported themes are explored in Table 72.

Table 72

Focus Group Responses–Elementary Educator Perspectives Describing Further Support

Coded Theme	Supporting Quote
Partnerships	"I think the three of our schools having its partnership. Even though we are in the same district. We are having a strong relationship to share practices, to share resources, to visit each other. That is where, I think, the flexibility of the district being supportive of [STEM] is essential. Them knowing what we are doing with funds. If we send four teachers to a school that will cost the school money."
	"We have parents who want to enroll their child at the school, but when asked why, what does STEM mean for you and your child, the parent cannot answer. There are people in the community too who have no clue what STEM means. I think it definitely could be promoted more, so everyone knows what it means."
STEM Accreditation	"I think right now we would love to just become a STEM school. We work so hard and I think that will just continue our momentum."
	"It is important that it is worthwhile, and it is time well spent. I think the three of us staying very close, and helping each other, and working together provides opportunities to learn because the rubric for accreditation is not a simple task. To be able to bounce ideas and talk about evidence, and what we have done and how to organize them is all crucial. The hardest part of it all is to prove it."
Common STEM Understanding	"We need something that gives us a better understanding of what STEM means. We need to be on the same page. So, you are selling it, so that the rest of the community buys into it. I want our definition to be the same because if I am going to come to you and I am going to ask you to support me, I better be hearing the same thing across the board and everybody be excited about it. I mean seriously we are marketing ourselves."
Quality and Consistent Professional Learning	"All the training that we did was not necessarily consistent, and that causes much confusion."

Table 72 displays some specific supporting quotes focused on the top further supported themes found in Table 36. The leadership focus group session provided many participants directing focus onto future STEM accreditation. Previously, it was mentioned each of the three schools are aiming for NC STEM Recognition. This certification recognizes exceptional STEM schools and programs (Public Schools of North Carolina, n.d.a). In addition to leadership participants, the executive director of elementary education (K-5) also attended the focus group session. This participant was

able to provide insight into one of the school's STEM implementation processes, as they were the principal when the idea was first presented to staff. Furthermore, the participant was able to provide a district perspective involving further support of the innovation:

> From a district perspective, it is to give these three schools as best we can the support, they need to make STEM happen because what they are doing is what is best for kids….and best for their future and their communities. So, helping them get what they need; whether it is providing funding, whether it is providing opportunities to collaborate on early release days. We want to make sure that these three schools especially have what they need to be successful. (Leadership focus group participant, personal communication, November 29, 2018)

From the teacher perspective, however, most participants focused on how STEM innovation could be further supported in their classrooms. Also, participants mentioned professional development opportunities attended were not necessarily uniform, in that different trainers approached the topic of STEM differently and were not in agreement on what STEM education should be for the school (Teacher focus group participant, personal communication, November 30, 2018). This statement led many participants at different schools to address how STEM could be further supported in the classroom through a common understanding of STEM. Particularly, one teacher participant mentioned STEM requires substantial funding and community involvement. For community partnerships to succeed and be beneficial to everyone, every staff member needs to have the same understanding of what STEM entails and why STEM is selected as the school's focus (Teacher focus group participant, personal communication, December 12, 2018).

For some participants, seeking and obtaining NC STEM Recognition would enforce all the hard work performed and would continue the educator's momentum. For some, developing a united STEM understanding for the school is how STEM could be further supported; though consistent, quality, and grade level specific professional learning opportunities would encourage educators to continue supporting the innovation. Further interruption of each of these findings and suggestions can be found in Chapter 5.

Summary of Research

Research Question 1. Research Question 1, "How can elementary educators' perceptions and understandings of the STEM innovation be described," addressed the interpretation of STEM terms for the educators involved in the study. Through this research question, the researcher acquired an understanding of how STEM education was described and how it relates to education for the different educators at the three researched schools. Data were collected using an explanatory mixed methods format and included examined teacher and leadership survey items and teacher and leadership focus group responses. Descriptive statistics were used to analyze results, and frequencies were collected and examined.

Review of perceptions and understandings of STEM items in the teacher and leadership survey showed a lack of understanding of STEM education. Many survey respondents identified STEM as including the four domain areas; however, only 40.9% of teachers and 33.3% of leaders were able to identify STEM as involving inquiry (problem-based) learning, and even fewer respondents could describe other elements of STEM. These findings were supported by the National Academies of Sciences, Engineering, and Medicine (n.d.) which reported members of the committee were unable to succeed in

determining a definition summarizing STEM education. In examining other STEM terms such as inquiry-based learning, EDP, active learning, and Next Generation Science Standards, a lack of understanding was also present. In inquiry-based learning, many respondents identified an understanding of engagement in questioning, which stems from the connection between inquiry and questioning; however, inquiry-based learning involves many components, such as investigating evidence, fostering curiosity, and critiquing and analyzing information. These components were primarily unmentioned, save for the investigating evidence component mentioned by 37.3% of teachers and 66.7% of leaders. The understanding of EDP also saw a lack of understanding. Many teachers provided EDP consisted of building or constructing as well as brainstorming possible solutions. Leadership respondents responded EDP consisted of reviewing, redesigning, and retesting as well as brainstorming possible solutions while completing inquiry in a step-by-step process; however, many additional elements of EDP were not provided in either educator descriptions of the STEM term. This discrepancy in understanding can be attributed to a lack of understanding of the instructional practice. Also, understanding of active learning was examined, and analyzed data revealed teachers and leaders struggled in defining active learning and did not express a common language or understanding when describing the learning. When Next Generation Science Standards were described, many educators did not know what the standards entailed. Many educators understood standards were provided; however, many educators could not describe the standards.

Research Question 2. Research Question 2, "To what extent are STEM instructional practices being implemented," addressed perspectives of implementing

STEM-based instructional practices and was rooted in the application of STEM instructional practices. Through this research question, the researcher acquired an understanding of STEM instructional practices utilized at each of the three researched schools. To achieve this understanding, the researcher collected quantitative data from a teacher and leadership survey as well as qualitative data from teacher and leadership focus groups. Mode was also utilized to gain an understanding of instructional practices.

Review of STEM instructional practices showed educators discuss STEM; however, 12.1% of teachers only rarely or sometimes discuss STEM education with fellow teachers, and even fewer teachers collaborate with other teachers on STEM education. In addition, data analysis revealed 40.5% of teachers and 50% of leaders have only implemented STEM to some extent in the schools; and 62.3% of teachers responded they have implemented STEM not at all, to a small extent, or only to some extent in their classrooms. However, many teachers responded they utilize STEM instructional practices in the classroom, and leaders described observing the various STEM-based instructional practices as well. However, there were inconsistencies between educator perceptions of use when utilizing EDP. Even though EDP is not often encouraged by leaders, many teachers responded they were encouraged and often utilize the instructional practice in the classroom. Lack of understanding of EDP could impact teacher perceptions of the instructional practice. In addition, when examining the encouragement in use of Next Generation Science Standards, perceptions varied greatly. While the majority of leadership respondents responded they sometimes encourage the use of the standards, teachers replied with mixed responses of never, rarely, sometimes, usually, or always. This difference may be due to a lack of understanding of the standards.

Research Question 3. Research Question 3, "How do elementary educators characterize successes and challenges in implementing the STEM innovation," was shaped to address the perceptions of successes and challenges in implementing STEM and was rooted in the notion that innovation implementation always involves successes and challenges. Through this research question, the researcher acquired an understanding of successes and challenges associated with implementing the STEM innovation. To gain this understanding, the researcher collected quantitative data from a teacher and leadership survey as well as qualitative data from teacher and leadership focus groups. Data were collected using an explanatory mixed methods format and included examined teacher and leadership survey items and teacher and leadership focus group responses. Descriptive statistics were used to analyze results, and frequencies were collected and examined.

Quantitative data analysis revealed teachers and leaders agreed on the top three characterized supports needed to implement STEM successfully. They perceived the top supports needed were STEM understanding, materials, and professional development. In addition, more than half of both teacher and leadership respondents responded leadership teams provided teachers with STEM professional development, materials, and encouragement as well as leaders applied for grants to help support funding of STEM. Also, when describing successes, quantitative data analysis revealed the majority of teacher respondents experienced personal growth during the implementation phase. Additionally, 28.5% of teacher respondents described the success of student engagement, describing how STEM education has enabled students to become excited about learning and provided student enjoyment when STEM lessons were incorporated into student

learning; however, only 17.9% of teachers described student perseverance, and 6% provided achievement as a success. Also, only 7.5% of respondents described the school has grown during the process and had created teams focusing directly on STEM innovation.

When describing challenges, the majority of teachers responded leadership team members could have provided teachers with quality STEM lessons in their implementation of the innovation. The majority of leadership members agreed with this perspective. Also, quantitative analyzed data revealed the majority of teacher respondents responded they could have created quality STEM lessons with colleagues to help aid in the successful implementation of STEM innovation. When examining the top challenges elementary educators faced when implementing STEM innovation, data revealed the majority of teacher participants responded the top three challenges were difficulty in creating lessons, difficulty in changing mindset, and difficulty in team planning. Similar to teacher respondents, when leaders examined challenges, the top challenge involved changing mindset; however, data also revealed leadership respondents could not characterize only three important challenges. Instead, leadership quantitative data revealed four challenges: a lack of STEM preparation in the teacher education program, difficulty in creating lessons, difficulty in team planning, and changing mindset. When teachers described challenges of implementing STEM innovation, the majority of teachers responded they were challenged in the area of time. Many of these educators expressed finding time to research, plan, teach, and implement the innovation was difficult. Also, some respondents described being unprepared to implement STEM, and 20.9% of respondents also described there was a lack of STEM resources which hindered

them when implementing the innovation. Many of these respondents described STEM resources as being limited or not designed for younger elementary students. Meanwhile, leadership respondents described challenges in helping teachers implement the innovation. Quantitative data analysis revealed the majority of leaders described it was a challenge encouraging teachers to shift their mindset towards instructional practices that are unfamiliar.

Research Question 4. Research Question 4, “To what extent are elementary educators supported in their implementation of the STEM innovation,” was shaped to address perspectives of current supports received. Through this research question, the researcher acquired an understanding of supports received encouraging educators to successfully implement STEM innovation and was rooted in the literature review which described the four supports: funding, changing mindsets, resources, and professional learning. Data were collected using an explanatory mixed methods format and included examined teacher and leadership survey items and teacher and leadership focus group responses. Descriptive statistics were used to analyze results, and frequencies were collected and examined.

Quantitative data analysis revealed the majority of teachers replied the school received funds for implementing STEM innovation. Teachers responded funds were used for resources and towards STEM learning areas. Leadership respondents agreed with the teachers’ pronouncement. Leadership respondents also responded the majority of funding for the innovation was achieved through grants.

In addition to funding, research also examined the support of the growth mindset. Teachers focused responses on support provided by leaders and fellow teachers.

Teachers responded leaders supported them with STEM resources. Also, 29.9% of teachers replied leaders provided them encouragement. When describing fellow teacher support, the majority of teachers replied that fellow teachers collaborated with them in differing ways supporting their growth mindset. Also, 28.6% mentioned some teachers shared STEM resources. Leadership respondents focused responses on support provided by district leaders and how they supported teachers' growth mindset. Respondents provided a difference in perspectives involving how district leaders supported them through the implementation process; however, leadership respondents responded district leaders did support them through the implementation process when examining leadership perspectives involving how school leaders supported teachers' growth mindsets through the implementation process. Quantitative data analysis revealed the leaders supported teachers by providing them with encouragement.

In addition to supporting the growth mindset, educators also examined support of resources. Both educators responded professional development was a support given. When examining professional development, most educators described receiving STEM professional development; however, 2.9% of teacher respondents replied they had not received professional development, and only 30.4% of teachers received some school offered STEM professional development. When describing STEM-based professional development, teachers replied they had received professional development opportunities centered around inquiry-based learning and STEM lesson design. While these elements encourage growth with the innovation, they do not support educators in transitioning traditional instructional practices to practices supporting integrated interdisciplinary learning practices that STEM requires.

Research Question 5. Research Question 5, "How could the STEM innovation be further supported in the elementary classroom," was shaped to address how the four supports of STEM innovation (funding, growth mindset, resources, and professional learning) could further be supported now that the innovation has been implemented for multiple years in each of the schools involved in the study. This question found its roots in the development of building continuous support in encouraging permanent growth of educators' STEM understanding using the innovation. Through this research question, the researcher acquired an understanding of how STEM education could further be supported. To gain this understanding, the researcher collected quantitative data from a teacher survey and a leadership survey as well as qualitative data from teacher and leadership focus groups.

When educators examined further funding of STEM, educators described working towards applying for either federal, state, or local grants could further support funding of STEM. Leadership respondents also responded they could rely on community partnerships for future funding of the innovation. Also, educators examined how the growth mindset could be further supported focusing on school leader support of the innovation as well as one thing the individual could do to support further mindset growth. Teachers responded school leaders providing further STEM professional development could support their further mindset growth; however, school leaders responded they could either model the STEM mindset or provide feedback on STEM lessons.

These elements were also present in the idea of one thing the individual could do to support further mindset growth. In examining further resources needed to support future STEM implementation actions, teachers responded with four further resources

needed for successful STEM implementation, namely opportunities to visit implementation STEM schools, access to STEM lessons, additional STEM professional development, and access to funds. Leadership data revealed five (four resources received the same number of replies) further resources needed for successful STEM implementation were additional STEM professional development, opportunities to visit successfully implemented STEM schools, access to lessons, access to curriculum, and access to funds. When educators examined further professional development needed to support future STEM implementation in the elementary classroom, quantitative analyzed data revealed the majority of teacher respondents responded EDP professional development as well as the creation of real-world problems would help in successfully implementing STEM innovation. Leadership respondents supported the idea of EDP professional development is needed to encourage successful implementation of STEM, though leadership respondents responded professional development in active learning and the creation of real-world problems is equally as important.

Chapter 5: Conclusions

The U.S. Department of Commerce (2017) disclosed from 2005 to 2015, employment in STEM professions increased more rapidly than non-STEM professions. Specifically, STEM professions grew 24.4% compared to non-STEM professions, which only grew 4.0% (U.S. Department of Commerce, 2017). Furthermore, STEM professions are expected to grow 8.9% from 2014 to 2024 (U.S. Department of Commerce, 2017). Even though this information prioritizes a need for the nation, it also establishes a need in the education system. According to the U.S. Department of Education (n.d.), all adolescents should be "prepared to think deeply and to think well so that they have the chance to become the innovators, educators, researchers, and leaders who can solve the most pressing challenges facing our nation and our world, both today and tomorrow" (para. 3); therefore, many schools are investing in STEM education to equip learners in developing inquiry skills that will be beneficial in strengthening the four discipline areas of science, technology, engineering, and mathematics.

Elementary schools are less likely to implement STEM because of many impediments (Milgrom-Elcott, 2018). One reason is because elementary teachers do not specialize in just one particular subject area. Instead, elementary teachers are required to teach multiple subjects as well as teach a "massive range of concepts, behaviors and social norms to young children" (Milgrom-Elcott, 2018, para. 3). Furthermore, Milgrom-Elcott (2018) argued ongoing support, such as professional learning, for STEM innovation is limited for elementary institutions; however, research has shown STEM understanding is beneficial in elementary years since this exposure leads to interest in the secondary and postsecondary years and creates students who can think critically through

instructional practices supporting creativity and innovation (Engineering for Kids, 2016; SRI International, 2018).

Summary of Research

The purpose of this research was to investigate elementary educators' perspectives of implementing STEM innovation in three area elementary schools including the strengths and challenges associated with implementation. Furthermore, the study aimed to describe to what extent elementary educators are supported through the implementation process as well as how the innovation could be further supported in the elementary classroom. Throughout the study, an explanatory sequential mixed methods design was utilized and supported by a postpositivist theoretical framework. Through this theoretical framework, both quantitative and qualitative observations and measurements of those involved in the study were collected, leading to a complex explanatory range of facts (Butin, 2010; Clark, 1998; Creswell, 2014; Fischer, 1998).

A conceptual framework was applied to focus the postpositivist paradigm connecting STEM implementation and integration to how people learn (Kelley & Knowles, 2016). Using Kurt Lewin's model of organizational change, which correlates with elementary educators' need to change and shift instructional practices towards the STEM innovation, the study spotlighted the organizational change process required in implementing innovation. Moran and Brightman (2001) described change as the practice of renewing the focus, configuration, and abilities of an organization so they may serve the changing needs of those they serve; however, the change effort with regard to implementation of STEM instruction and learning is magnified at the elementary level due to several factors (Milgrom-Elcott & Blackwell, 2016).

Despite the importance of STEM instruction, it is difficult to implement in the elementary setting for multiple reasons including the generalist nature of elementary school teachers (Nadelson et al., 2013), the traditional isolation of subjects in schooling (Epstein & Miller, 2011; Fryer, 2015; Milgrom-Elcott & Blackwell, 2016), a lack of a clear definition for STEM learning (English, 2016; National Academies of Sciences, Engineering, and Medicine, n.d.; Zollman, 2012), and inadequate professional learning and resources to elementary teachers and schools wishing to implement STEM (Chalmers et al., 2017; “Changing mindsets: STEM is not content areas in isolation,” 2015; Chiu et al., 2015; Hansen, 2014; Ledbetter, 2012; Office of Innovation and Improvement, n.d.). Combined with all of these reasons, the literature review also examined change theory and the difficulties and roadblocks that can occur when trying to implement large-scale change of this nature (Alvesson & Sveningsson, 2008; Glieck, 1987; Hussain et al., 2016.

With a district push for schools to establish choice programs, school leaders in three elementary schools within a demographically diverse district began implementation of STEM innovation. Through utilizing both teachers and leadership perspectives and understandings of the innovation, the researcher identified opinions and perceptions of STEM in the elementary locale. This research worked to acquire an understanding of how STEM education was described and how it relates to education for the different educators. It also examined STEM instructional practices, successes, and challenges linked to implementing STEM and support for the innovation.

As a result of this research, this sequential explanatory mixed method designed research sought to gather quantitative data from teacher and leadership surveys and qualitative data from three teacher focus group sessions and one leadership focus group

session to answer the resulting research questions:

1. How can elementary educators' perceptions and understandings of the STEM innovation be described?
2. To what extent are STEM instructional practices being implemented?
3. How do elementary educators characterize successes and challenges in implementing the STEM innovation?
4. To what extent are elementary educators supported in their implementation of the STEM innovation?
5. How could the STEM innovation be further supported in the elementary classroom?

These five research questions were based on a postpositivist paradigm and centered around the conceptual framework of Kurt Lewin's model of organizational change to ensure the research remained centered around elementary educator perspectives and understandings. The study worked to gain perspectives and understandings of both teachers and administrators in implementing the STEM innovation through both surveys and focus groups.

Interpretation of Results

Zollman (2012) wrote, "we now are in the STEM generation" (p. 12); and a need exists for those involved with the innovation to become STEM literate. In becoming STEM literate, it is necessary to shift practices, knowledge, and methods and develop an understanding of the innovation (Zollman, 2012). Perceptions of STEM education and supports, such as adequate professional learning and resources, can influence educators' understanding and perspective of the innovation. Analysis of data related to the five

research questions reflecting this understanding was presented in detail in Chapter 4 and is summarized in this section.

Elementary educators' perceptions and understandings of STEM innovation. In this study, elementary educators' perceptions and understandings were described. Incorporating the interpretation of STEM terms for the educators involved in the study specified understanding of STEM for these participants. Analysis of the data revealed the majority of elementary educators in this study recognize STEM education involves the four disciplines; however, less than half of educators described the innovation involves inquiry-based learning or other components such as real-world active learning practices. Educators also examined their understanding of STEM terms such as inquiry-based learning, EDP, active learning, and the Next Generation Science Standards. These STEM terms also revealed a lack of STEM understanding. The majority of educators in the study described basic aspects of each term (questioning, building, brainstorming, and engagement), but data revealed a complete understanding of STEM is not well developed. These data revealed elementary educators have a basic understanding of STEM innovation, but they have not completely become STEM literate.

This lack of understanding of STEM, for both teachers and leaders, is supported by research in which STEM has been described many ways (Burke et al., 2014; Honey et al., 2014; Moore & Smith, 2014; Rennie et al., 2012; Vasquez, 2015; Vasquez et al., 2013). In addition, the National Academies of Sciences, Engineering, and Medicine (n.d.) reported members of their committee were unable to succeed in determining a definition summarizing STEM education. Many STEM definitions utilize the four discipline areas of science, technology, engineering, and mathematics in combination

with inquiry-based (project-based) learning; however, they are vague in providing an understanding of STEM education. This study reflected the lack of STEM understanding for educators. A proposed sequence to develop individualized elementary educator understanding of STEM innovation for an elementary school for an understanding of STEM education was developed. This sequence will be presented in detail in the implications section of this chapter.

STEM instructional practices. STEM instructional practices were the focus of Research Question 2, which was shaped to address elementary educator perspectives of implementing STEM-based instructional practices and was rooted in the application of STEM practices. Through this research question, the researcher acquired an understanding of STEM instructional practices utilized at each of the three researched schools.

Review of STEM instructional practices showed elementary leaders discuss STEM education with teachers, and teachers often discuss STEM education with leaders; however, 12.1% of teachers in the study only rarely or sometimes discuss STEM education with fellow teachers, and even less teachers collaborate with other teachers on STEM education. In addition, teachers and leaders examined the extent STEM has been implemented. Data analysis revealed 40.5% of teachers and 50% of leaders responded STEM innovation has only been implemented to some extent in the schools; and 62.3% of teachers responded they have implemented STEM either not at all, to a small extent, or only to some extent in their classrooms. This may be due to a lack of understanding of STEM innovation. Each of the STEM-based instructional practices explored and examined in the study is discussed in this section.

Inquiry-based learning. When educators in this study examined the STEM-based instructional practice of inquiry-based learning, almost 90% of teachers identified the instructional practice involved engagement in questioning, and more than half of teachers responded the practice involves proposing solutions; however, many characteristics of inquiry-based learning were not identified in educators' understanding of the instructional practice. Also, when educators examined the use of inquiry-based learning in the classroom, the majority of teachers responded they only use the instructional practice sometimes; however, the majority of leaders responded they usually observe the practice being used in the classroom. This discrepancy may result from a lack of understanding of the instructional practice. These findings are confirmed by the United States Department of Education (2007) document *Report of Academic Competitiveness Council*, which stated there is lack of evidence supporting effective STEM practices. Stone (2011) also supported these findings and maintained that while educational literature supports STEM efforts, a shortage in evidence of effective practices in STEM exists and more research is needed in understanding effectively integrating STEM instructional practices.

Many reasons exist for lack in understanding of STEM-based instructional practices, other than a lack of STEM understanding. Blowers (2017) and Freeman et al. (2014) contributed this to STEM education requiring educators to change traditional instructional practices to ones supporting the interdisciplinary active learning approach and that when faced with the requirements of the innovation, many educators are nervous to step away from the comfort of traditional instructional approaches. Also, a lack of quality professional learning involving the practice could impact the understanding of the

educator. Ejiwale (2013) mentioned that the quality of professional learning available to prepare educators in STEM was weak. This was revealed in the focus group sessions in which participants focused on how the innovation could be further supported was through quality STEM professional learning opportunities in which all instructors have the same understanding of STEM; therefore, confusion involving what constitutes inquiry-based learning and how it is facilitated was seen in the discrepancy between the educators.

Engineering design process. When educators in this study examined the STEM-based instructional practice of EDP, almost half of the teacher respondents identified the instructional practice involved brainstorming possible solutions and building of a prototype. School leaders provided the instructional practice is performed throughout a series of steps in which review, redesign, and retesting is paramount. These connections were confirmed by Roth (1973) who described EDP as a sequence of events engineers complete to solve solutions to a problem; however, the EDP model involves many components in each of the design steps, and less than half of educators could identify each step. Also, when educators examined the use of EDP in the classroom, the majority of teachers responded they only use the instructional practice sometimes, and only 21.7% of teachers responded they usually use the practice; however, 33.3% of leaders responded they sometimes or usually observe the practice being used in the classroom. This inconsistency between educators is an indicator of the lack of communication between administration and teachers. A lack of understanding of EDP can impact an educator's use of the practice, especially if they lack experience in engineering. Chalmers et al. (2017) supported this pronouncement, stating that many elementary educators are exposed to the math and sciences; however, many lack experiences in technology and

engineering integration using these subjects. This lack of experience can impact their beliefs and attitudes related to evolving traditional instructional practices and implementing change.

Active learning. When educators in this study examined active learning practices, the majority of educators responded active learning involved engagement and students learning actively; however, active learning is a component of problem-based learning (inquiry-based learning) and EDP and incorporates multiple intelligences to solve real-world problems (Rosicka, 2016). These elements had a limited presence in educators' descriptions of the practice. This lack of understanding can be attributed to a lack of understanding of STEM education. Blowers (2017) wrote that educators, when faced with STEM requirements, are nervous to step away from traditional instructional practices; however, the reality is that active learning allows for flexibility in which group collaboration can increase student engagement (Blowers, 2017).

Also, educators examined the use of active learning activities in the classroom. The majority of teachers responded they sometimes use active learning activities involving STEM in the classroom; however, the majority of leaders responded they usually observe the practice in teachers' classrooms. This discrepancy can be related to a lack of STEM understanding and communication between the two educators. Wenger, McDermott, and Snyder (2002) acknowledged that when discussing organization change, sharing knowledge among an organization is critical for understanding to occur. When members of the organization act as a team and work out their insecurities with the innovation, understanding can begin to occur (Foss & Pedersen, 2002; Hakanson, 1993; Mind Tools Content Team, n.d.; however, if members do not communicate,

understanding of practices cannot develop.

Successes and challenges in implementing STEM innovation. Successes and challenges in implementing STEM innovation were the focus of Research Question 3, which was shaped to address educator perceptions of implementing STEM and was rooted in understanding of successes and challenges being an inherent part of the change process.

Successes. In this research question, educators in the study examined the top supports needed to implement STEM successfully. Both teachers and school leaders agreed in their perspectives, responding that the top supports included (1) STEM understanding, (2) materials, and (3) professional learning opportunities. Western Governors University (2017) supported findings involving professional development, citing continuous professional development is needed for educators to continue to learn and improve in their instructional practices. Data analysis also revealed leadership teams provided teachers with STEM professional development, materials, and encouragement; and leadership members applied for grants to help support funding of STEM. Encouragement to use innovation can result in positive attitudes and a willingness to shift current instructional strategies and is crucial for success (Al Salami et al., 2017). Also, when describing successes, quantitative data analysis revealed the majority of teacher respondents experienced personal growth during the implementation phase. Particularly when describing personal growth, one participant described collaboration among educators increased and eductors began working collectively to implement the innovation (Teacher focus group participant, personal communication, December 6, 2018). Additionally, 28.5% of teacher respondents described STEM education has encouraged

success in student engagement, as students become excited about learning. Also, one participant shared the innovation encourages students to translate STEM practices to other areas and creates individuals who can learn from mistakes, not getting discouraged in the process (Teacher focus group particiapnt, personal communication, December 12, 2018). STEAM Powered Family (2017) advocated for implementing STEM innovation in the elementary classroom citing "the greatest benefit of STEM is that it fosters that love of learning. Instilling that passion and drive to learn that is at its most crucial stage during the elementary years" (para. 7). Furthermore, Dweck et al. (2014) responded the STEM innovation develops growth mindsets and behaviors that instill lifelong learning in a world that is changing daily.

Challenges. Along with discovering successes, challenges associated with implementation were described. When educators in the study examined the top challenges faced when implementing STEM, the top three challenges involved difficulty in creating lessons, difficulty in changing mindset, and difficulty in team planning. Initiating STEM innovation practices requires significant undertaking and planning. This undertaking can influence the STEM mindset and can sometimes lead to barriers. Specifically, one participant described, "Be willing to let go. That is the hardest part. Accept mess and accept loudness. Accept not talking all the time. Let [students] be the talkers. Let them figure it out" (Teacher focus group participant, personal communication, December 6, 2018). Leaders responded the top challenge involved changing mindset. Dweck (2006) stated people either exhibit a fixed or growth mindset. Fixed mindset describes an individual whose patterns of thinking and understanding cannot be changed, while growth mindset describes a belief that effort can alter

intelligence and understanding. When describing challenges associated with STEM implementation, teachers expressed being time challenged and unprepared to implement the innovation. Hall and Hord (2015) wrote, "change is a process and not an event" (p. 10) and stipulated that fully operational implementation requires 3-5 years. However, when many institutions decide to implement innovation, they push for rapid implementation; therefore, those involved are unprepared. When describing a challenge involving time, many teachers expressed finding time to research, plan, teach, and implement the innovation was difficult. Boyle et al. (2013) revealed that when implementing any innovation, educators need knowledgeable occurrences to prepare for the innovation and become inspired themselves.

Many participants in the study explained STEM instructional practices require students planning, building, testing, revising, and retesting; however, additional time has not been added to the school day, and responsibilities have not decreased. Some participants explained that with testing and teacher accountability, a focus for state and local government, teachers often rely on traditional strategies requiring less time (Teacher focus group participant, personal communication, December 12, 2018). However, these strategies sometimes rely on memorization instead of grasping an understanding of the skill or objectives (Brown, Roediger, & McDaniel, 2014). Also, STEM education is expensive to maintain. A claim supported by Hunter (2017) disclosed, "Hands on materials for STEM often cost money" (para. 10). While it is essential for students to learn actively, funding of resources often is provided by the educator without reimbursement.

Developing support for the innovation. In addition to establishing an

understanding of STEM education and appropriate instructional practices, support for the innovation must be established for understanding to occur. This idea was the focus of Research Questions 4 and 5. Research Question 4, “To what extent are elementary educators supported in their implementation of the STEM innovation,” was shaped to address perspectives of current supports received and was rooted in the four supports of funding, changing mindsets, resources, and professional learning. Research Question 5, “How could the STEM innovation be further supported in the elementary classroom,” was shaped to address how the four supports of STEM innovation (funding, growth mindset, resources, and professional learning) could further be supported and found its roots in the development of building continuous support in encouraging permanent growth of educators’ STEM understanding using the innovation.

Quantitative data analysis revealed schools in this study received funding obtained through grants for implementing STEM innovation. Funds were used for resources and towards construction of STEM learning areas. When educators examined further funding of STEM, educators described working towards applying for either federal, state, or local grants to further support funding of STEM. Leadership respondents also responded they could rely on community partnerships for future funding of the innovation. Solochek (2012) supported this endeavor, citing that to accommodate the push for STEM innovation, many schools have begun transferring resources, locating public businesses interested in funding the innovation, and applying for private and federal grants.

In addition to funding, research also examined the support of the growth mindset. Teachers in this study responded leaders supported them with STEM resources and

provided them encouragement which encouraged growth of the STEM mindset. When describing fellow teacher support, the majority of teachers indicated that fellow teachers collaborated with them in differing ways supporting their growth mindset. School leader participants expressed district leaders supported their efforts through encouragement, and school leaders supported teacher efforts through encouragement.

In Research Question 5, educators examined how the growth mindset could be further supported. Teachers responded school leaders providing further STEM professional development could support further mindset growth; however, school leaders responded they could either model the STEM mindset or provide feedback on STEM lessons. These elements were also present in the idea of one thing the individual could do to support further mindset growth.

Each of these ideals are supported in the literature review. Hall and Hord (2015) wrote that regardless of legislation and government mandates, educators are the individuals who "will make or break any change effort" (p. 12). Support, or lack thereof, will either encourage an educator's growth mindset or allow the fixed mindset to take hold with regard to STEM education. Educators often need assistance in shifting their mindset and instructional practices. Without this support, success for the innovation could be prevented (Talley, 2017).

In addition to supporting the growth mindset, educators also examined support in the form of resources. Educators in this study responded professional development was a support given. When describing STEM-based professional development received, teachers replied they had received professional development opportunities centered on inquiry-based learning and STEM lesson design. While these elements encourage growth

with innovation, they do not support educators in transitioning traditional instructional practices to practices supporting integrated interdisciplinary learning practices that STEM requires. Also, not receiving quality STEM professional learning experiences can result in educators putting forth little effort towards implementing the innovation. As mentioned previously, educators often instruct the way they were taught as students, and extending instructional practices outside of their own learning experiences can be challenging ("Changing mindsets: STEM is not content areas in isolation," 2015). Changing this mindset takes practice and time. This is supported by Ledbetter (2012) who stated educators are not necessarily receiving professional learning experiences needed in the teaching of STEM.

Limitations

As mentioned in Chapter 1, with any research, limitations are part of the process and can influence the analysis of the discoveries (Price & Murnan, 2004). Although limitations are beyond the control of the researcher, a need exists for them to be addressed. Chapter 1 defined and discussed four limitations; however, the researcher discovered additional limitations during data collection and analysis of the explanatory sequential mix methods research. The four limitations addressed in Chapter 1 are reviewed below as well as additional restrictions discovered by the researcher.

Stages of implementation. Limitations in Chapter 1 indicated a limitation of different stages of implementation. Collected research data, from three elementary schools, was obtained in the researcher's school district. All three schools are at different points in their implementation process and towards NC STEM Recognition.

Implementation periods. As already indicated, research involving educator

perspectives for implementing STEM innovation occurred in the researcher's district and involved three elementary schools; however, each of the three schools began implementation of the innovation at different times. When district leaders pushed each of the district schools to establish choice programs, school leaders began exploring many options. Though establishing choice of STEM innovation did not coincide, each of the three schools began utilizing the innovation in consecutive years. Louis Armstrong began implementation of STEM innovation during the 2013-2014 school year. The next school year (2014-2015) saw Old Mountain Elementary begin implementation. The following school year (2015-2016) Heritage Elementary began their journey with STEM education. Since each of the schools involved in the research began implementation at different times, a limitation is found involving educator perspectives of implementing STEM instructional practices. Given that educators at the three schools have been instructing using STEM education for differing amounts of time, perspectives of implementing the innovation can vary.

Degrees of experience. A limitation discovered during the study involves varying degrees of experience with the STEM innovation. As previously mentioned, each school began implementing the innovation at different times. As a result, some educators have more experience implementing the innovation than others. Furthermore, each school has received diverse professional learning opportunities, which could affect their perspectives of implementing the innovation. Two schools, Old Mountain Elementary and Louis Armstrong Elementary, received a substantial grant from local cooperations. This grant provided support for the innovation in different ways for each school, one of them being professional learning; therefore, these different professional

learning opportunities can impact understandings and perspectives of implementing the innovation.

Survey responses. As previously discussed, the study involved the collection of quantitative data through the means of a survey. As a result of this tool, responses made by individuals during the research were outside the control of the researcher. The survey is designed to collect perspectives and understandings of the elementary educator at one specific time of collection. For this research, a collection of perspectives and understandings involving the elementary educator were gathered in October 2018. For the reason that the survey was given only once, collected data only measured these perspectives and understandings of the innovation at a single point in time.

Number of respondents. An additional limitation was discovered during survey collection. Creswell (2014) suggested a random sampling from each of the school's population to obtain statistically significant quantitative results of survey findings. Keppel and Wickens (2003) also supported this suggestion; however, the Krejcie and Morgan (1970) text suggested utilizing the National Education Association published formula for determining the sample size of the population. In Chapter 3, the utilized formula provided the number of teacher and leadership respondents needed to respond to the corresponding surveys. Formula results suggested 78 teacher respondents were needed, and eight leadership respondents were needed to respond to each survey; however, this sample size was not obtained. Instead, 69 teacher respondents replied to the teacher survey, and six leadership respondents provided their perspectives and understandings of STEM innovation.

Leadership responses connecting professional development. Another limitation

was discovered during data analysis of the leadership survey. Leadership survey questions 43 and 44 asked respondents to write the total number of all school-offered professional development sessions during the 2017-2018 school year as well as the total number of STEM professional development sessions offered. One respondent provided information in a number range, instead of a specific number. Furthermore, one respondent provided information involving STEM meetings, STEM professional expert training, and ongoing support instead of addressing the number of professional development and STEM professional development sessions. The other four respondents provided numbers for these responses; therefore, the research quantitively analyzed all single numbers and marked these responses as "other." The responses labeled "other" were discussed in the tabular format following addressed analyzed data.

Survey distribution. Another limitation to address focuses on survey distribution. Mentioned previously, the surveys were to be created using the online program SurveyMonkey; then the link was to be sent to school leaders for distribution to school educators. While this sequence of events did occur, a district safety online issue presented itself to numerous respondents. For reasons unknown, the survey distribution website SurveyMonkey presented a safety issue for educators taking the online educator surveys on the school network. At different points in the survey, respondents were presented with an error message and were unable to complete the survey; however, SurveyMonkey still collects these survey results with the label of incomplete. Knowing the issue, the researcher chose not to analyze data for the 13 incomplete surveys, as the data would skew results. To alleviate the problem, many educators overcame the internet safety issue by responding to the survey at home on a network. Also, school leaders

provided paper copies of each survey to educators and sent them to the researcher at the end of survey collection.

Focus group. As previously mentioned in Chapter 1, another limitation of the research, focused on the educators involved in the focus group sessions. The individuals involved in the focus group sessions were volunteers. Considering that participation is voluntary, the participant sample is outside the control of the research. The small size of the sample might not express the beliefs of a larger population; therefore, this limitation needs to be addressed.

Recommendations for Practice

Despite the limitations, findings from the study in combination with information gleaned from the literature review provide multiple avenues for recommendations. These recommendations relate to a process of developing a clear understanding of STEM education at district and site levels, specific steps schools can implement to support STEM education at their site, and ways for schools and districts to build on successes and minimize challenges related to effective STEM implementation.

Developing elementary educator understandings of STEM innovation. Many elementary educator participants in this study understand STEM innovation involves science, technology, engineering, or mathematics but were unable to stipulate as to what the innovation meant for the school. Through quantitative and qualitative analysis, a proposed sequence to develop individualized elementary educator understanding of STEM innovation for an elementary school was developed.

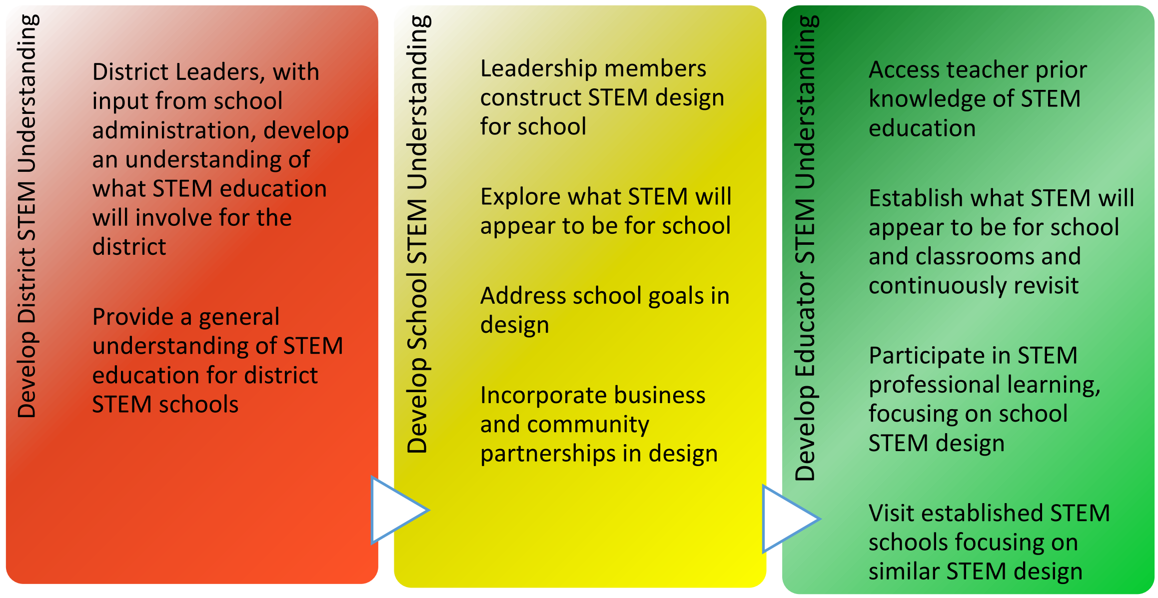

Figure 43. Proposed Sequence to Develop Individualized Elementary Educator Understanding of STEM Innovation for an Elementary School. This figure displays an order in developing elementary educator understanding of individualized STEM innovation for a school.

As shown in Figure 43, to aid elementary educators in understanding what STEM innovation means for their school, an understanding of the innovation must first occur at the district level; then the school must develop and construct the STEM design matching school goals and partnerships; and finally, educator STEM understanding can be established.

Develop district STEM understanding. Many study participants stated that a lack of understanding of STEM education before implementation hindered them in understanding the direction the innovation was to take; however, all study participants understood the innovation appears to be different at each implementation location based on needs and clientele in which the school serves. Specifically, one school involved in the study experienced new leadership after a few years of implementation under a

previous administrator. Both administrators differed in their understanding of the innovation; therefore, staff members expressed confusion over the innovation since views of the innovation differed between each administrator. Thus, having the district develop a general understanding of STEM education would equip all schools involved with the innovation a universal understanding of what the innovation entails. To generate this district understanding, district leaders, in collaboration with school administration, must develop a general definition of STEM education. In developing this general definition of STEM, leaders should decide upon which agency to gain STEM recognition and build district understanding around their STEM accreditation rubric. Each STEM accreditation agency differs in their understanding of STEM education; therefore, deciding which agency to achieve STEM recognition from is needed. Next, members should highlight prominent features of the rubric to distinguish the district's approach to STEM education. With input from the STEM rubric and members, district STEM understanding can be achieved.

Develop school STEM understanding. The next section of Figure 43 illustrates after developing district STEM understanding, individual schools must develop their targeted STEM understanding. This targeted understanding defines what STEM education would look like for the school. To achieve this goal, leadership members work together to construct the school's STEM design (layout) and explore how STEM education will materialize and become visible. To achieve this design, school leaders construct and organize how STEM will be implemented and how STEM will be presented (i.e., agriculture based, arts centered, engineering driven). To maintain authenticity for each school, school goals need to be aligned to the individual school.

Furthermore, STEM education maintains continuing community and business engagement is crucial for STEM experiences (Friday Institute for Educational Innovation, 2013); therefore, these partnerships need to be addressed and developed in the school's STEM understanding for these partnerships contribute to the STEM design of each school.

Develop educator STEM understanding. Once the school has developed STEM understanding and defined what the innovation will appear to be, educators need to develop their STEM understanding. To best develop this understanding, school leadership needs to access prior teacher knowledge of STEM education. Since there are multiple understandings of the innovation, school leaders need to comprehend the level of understanding of the teachers in their building to establish the STEM design for the school and classrooms. This step needs to be continuously revisited to maintain consistent understanding for all educators. Similarly, before the innovation begins implementation, participants need to take part in professional learning focused on the STEM design for the school. At one elementary institute, study participants acknowledged the school performed this crucial step to develop educator pedagogy. Together, participants discovered and shaped what STEM innovation would be for the school through a STEM book study. They expressed this step was crucial for each participant to buy in to the innovation and gain a STEM mindset before the innovation was implemented. Together, educators discovered integrated STEM practices, explored potential barriers to interdisciplinary STEM practices, addressed STEM real-world learning, and connected instructional practices to real-world STEM instructional practices. Additionally, the elementary institute explored professional learning

opportunities focusing on developing problem-based learning and integration before STEM education was expected to be used. Many other study participants expressed that they desired their school had achieved this step before the school began implementation. Explicitly, one study participant conveyed partaking in professional learning to define STEM at the site would ensure "everyone is on the same page … making it easier to transition from grade level to grade level" (Teacher focus group participant, personal communication, December 12, 2018). Performing these steps before STEM implementation develops a common understanding of the innovation and enables educators to understand and plan for what the innovation entails.

Furthermore, developing this common understanding of STEM education, from both district and school educators, would enable communication to support community understanding of the innovation. Notably, one teacher focus group participant described a conversation between themselves and a parent, stating the parent chose to send their child to the elementary school because the school is working towards organizing itself as a STEM certified school; however, when asked why they thought the innovation would be beneficial for their child, the parent was unable to express a reason (Teacher focus group participant, personal communication, December 12, 2018). Therefore, having this understanding in place before implementation would benefit the community and industry partnerships. Additionally, to develop educator STEM understanding, educators need to visit established similar STEM-focused schools. This idea promotes understanding and strengthens STEM experiences for the educator. It also promotes a culture of communication and collaboration among STEM schools.

Developing support for STEM innovation. In addition to establishing an

understanding of STEM education and instructional practices benefiting the innovation, support for the innovation must be established for the innovation to be understood. Furthermore, continuous support for the innovation encourages educators to model a STEM mindset both inside and outside the classroom. Hall and Hord (2015) wrote, "Developing, articulating, and communicating a shared vision of the intended change" (p. 31) is the first step in moving forward with a change in innovation. Often, this shared vision of change develops through the combined efforts in the creation of the school's mission and vision. Hall and Hord communicated, when implementers encourage a shared vision, support for the innovation can be distributed and planning for the innovation can begin; thus, it is essential for support to be established before implementation of the STEM innovation. This support can be found in funding of the innovation, gathering and distribution of materials, professional learning opportunities, and encouragement in using new practices, leading to the development of the STEM mindset. Through the collected quantitative and qualitative data, an Implementation Support Sequence Diagram was constructed shown in Figure 44.

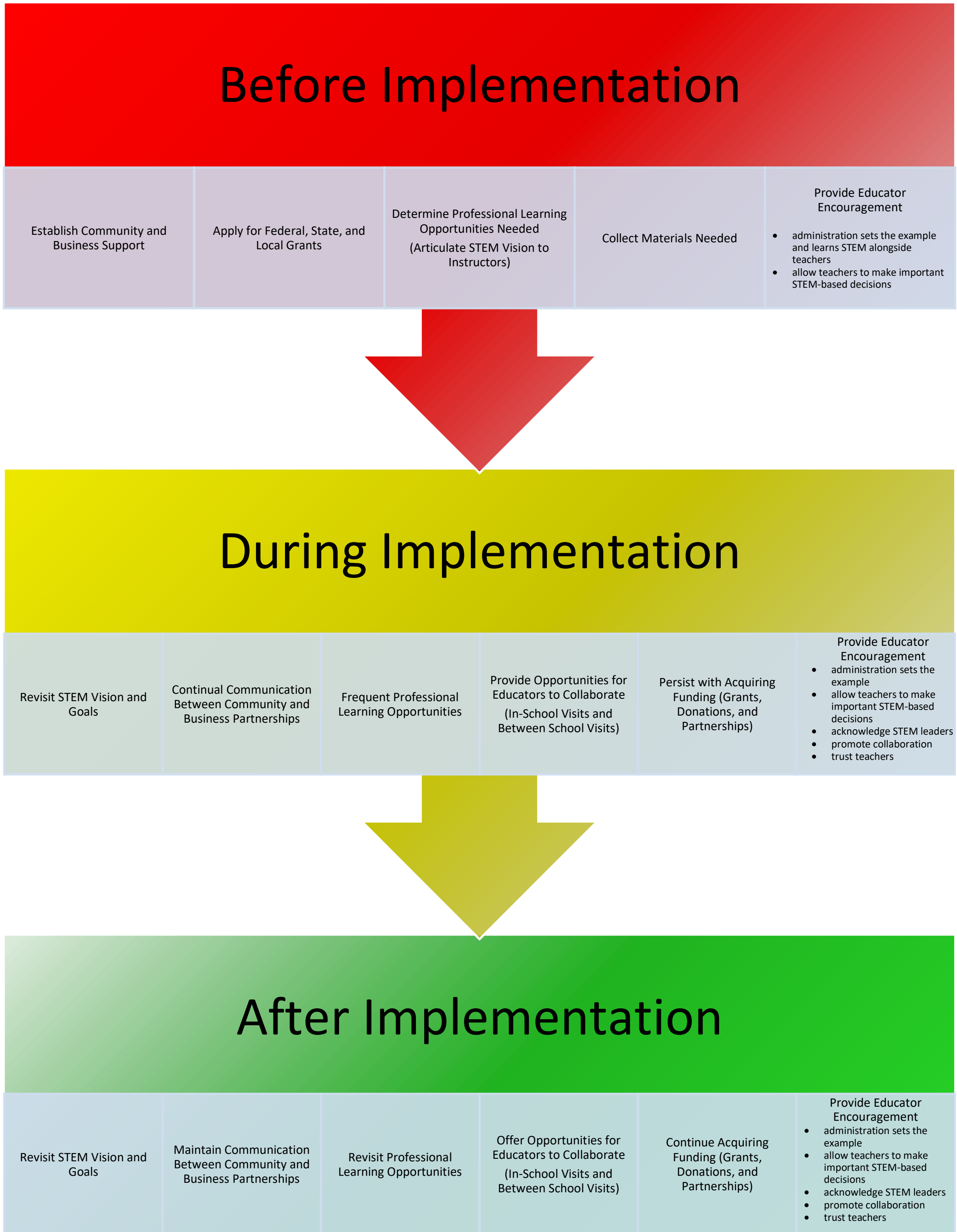

Figure 44. Implementation Support Sequence Diagram. This figure displays before, during, and after implementation support sequence, schools can visit to understand the series of events needed to develop and establish support for the STEM innovation.

Figure 44 displays the developed Implementation Support Sequence Diagram established as a result of findings from the study. Support for the innovation needs to be provided continuously, not just at the onset of implementation. It requires constant upkeep to establish and maintain resources, understanding, and success of the innovation; therefore, support for the innovation begins before implementation and continues after implementation.

Before implementation. Support for the innovation needs to be continuous; however, before the innovation is to be implemented, support for the innovation must be obtained and applied. As mentioned previously, federal funding for the innovation is limited; therefore, community and business support for the innovation aids in alleviating some funding issues. However, to encourage community and business support, communication of the school's STEM design plan is essential to create a partnership, providing opportunities that extend to the classroom (Friday Institute for Educational Innovation, 2013).

In addition to launching community and business support, grants are useful in providing funding. Two participating schools received grants over $50,000. This money provided both schools with a means to acquire professional development, build STEM learning centers, and obtain materials needed to encourage integrated learning using STEM instructional practices. All these supports are required to transition from traditional practices towards integrated interdisciplinary instructional practices.

Furthermore, professional learning opportunities involving STEM education and instructional practices are required for knowledge of the innovation as well as an understanding of changes in instructional practices. As previously mentioned, STEM

innovation is becoming typical in the elementary setting; however, how the educator comprehends, conceptualizes, and interconnects the content of the innovation influences the learning capabilities of students (Diefes-Dux, 2014; Estapa & Tank, 2017). Therefore, quality professional learning opportunities focusing on elementary learners is fundamental. Unfortunately, many study participants were exposed to a limited number of STEM instructional practices resulting in partial implementation in the classroom. Furthermore, a few teacher and leadership participants acknowledged STEM professional development received was not aligned to the elementary level, nor was it helpful; therefore, before professional learning opportunities transpire, the administration needs to determine professional learning opportunities desired and communicate this desire to professional learning instructors. Also, the administration needs to articulate the school's vision to these instructors to formulate a consistent understanding of the innovation between the school and all instructors involved. Regrettably, for one school, participants were subjected to professional learning instructors who did not agree on STEM education; therefore, these participants were told differing opinions concerning what constitutes STEM and what does not (Teacher focus group participant, personal communication, November 30, 2018). Creating and communicating the school's vision of STEM will create unity among all participants.

Once professional learning opportunities have been explored, the collection of materials needed to implement STEM must be gathered. Since STEM education requires students to participate actively in their learning, many materials are needed for integrated lessons. Many STEM professional learning opportunities provide educators with ideas involving future STEM lessons; therefore, materials needed are gathered, and a

centralized area housing the materials is constructed. Many participants in the study expressed they purchased materials themselves; however, if community and business support is established as well as federal, state, and local grants are obtained, there would be no need for educators to purchase materials themselves, eliminating waste and creating a communal area to access materials in the process.

In addition to collecting needed materials, leadership members need to provide educator encouragement before implementation begins. Previously, it was mentioned that changing an educator's mindset to include the integrated and interdisciplinary STEM mindset can be difficult; therefore, educators need encouragement establishing they can achieve and implement STEM education. Mindset, according to Dweck (2006), involves how a person views and handles situations. Their mindset plays a part in either success or failure, and a person can either express a fixed or growth mindset (Dweck, 2006); therefore, encouragement for STEM innovation is essential at the beginning. Encouragement is provided to inspire and stimulate educators' efforts and improvement in STEM education. It provides an opportunity for educators to grow in their STEM understanding and contributes to their growth mindset. To provide encouragement throughout the before implementation stage, school leaders can (1) set the example and attend as well as participate in professional learning opportunities with fellow educators, and (2) allow teachers to help make important STEM-based decisions. These two encouragements are also seen during and after implementation.

***During implementation*.** As mentioned previously, support for the STEM innovation needs to be continuous. During the implementation of STEM, in referencing back to the Implementation Support Sequence Diagram, schools must revisit the STEM

vision and goals. This step is essential in maintaining the STEM vision of the school. Also, this phase is crucial in maintaining STEM momentum and encouraging participants to be united in educational goals. The University of Nebraska at Omaha STEM Leadership and Strategic Planning Committee (2013) agreed with this pronouncement, citing strategic plans and goals need to be often revisited as STEM innovation efforts grow. Furthermore, revisiting goals of the innovation will ensure all educators are united in their understanding of the initiative.

In addition to revisiting the STEM vision and goals, continual communication between community and business partnerships necessitates action. Iowa Governor's STEM Advisory Council (2017) declared partnerships are significant to STEM education and promote positive transformations. Not only do partnerships allow businesses and organizations to contribute to the community, but they also initiate students to real-world learning. Maintaining continual communication provides not only support but resources as well for both partnerships.

On top of continual communication between community and business partnerships, frequent professional learning opportunities are required during the implementation phase. Educators achieve basic STEM understanding before implementation; however, during the implementation process, questions arise, and continuous professional learning opportunities provide support for these questions as well as "enhance the quality of STEM teaching" (Learning from Innovation and Networking in STEM, n.d., p. 6). However, school administration needs to stress the vision and goals of STEM education to professional development instructors to ensure all individuals are working together cohesively.

During implementation, school administration also needs to provide opportunities for educators to collaborate. This collaboration can be performed within or between schools. As mentioned previously, during the implementation of STEM innovation, questions arise. Many times, educators require other educators to discuss innovation; therefore, these opportunities are essential in building STEM mindset and growth of the innovation. Many participants in the study mentioned the school provided collaboration opportunities for educators to work together in developing STEM lessons. For several participants, these opportunities enhanced understanding of the innovation and allowed participants to unite in creating STEM lessons (Teacher focus group participants, personal communication, December 6, 2018). Furthermore, the majority of participants stated the most significant challenge faced when implementing STEM innovation involved creating STEM lessons. Allowing educators opportunities to collaborate can alleviate misunderstandings. Also, providing opportunities for teachers to visit other classrooms in the school or other STEM schools affords additional STEM strategies and understanding of the innovation. Some participants discussed the value in visiting other STEM schools by providing them opportunities to communicate with other educators engaging in the same integrated instructional practices as well as viewing the innovation in action (Teacher focus group participants, personal communication, November 30, 2018).

In addition to providing opportunities for educators to collaborate, administrators are encouraged to persist in acquiring funding through different opportunities during the implementation phase. Funding is required to receive quality professional learning, opportunities for educators to visit STEM schools, establishing and maintaining

materials, and upkeep of STEM learning areas. Even though funding is established before implementation begins, opportunities to acquire additional funds should be a continuous effort for many educators to enhance the innovation.

Additionally, administration as well as teachers should encourage STEM innovation. Not only should encouragement of STEM education be provided before implementation, but it should also be prevalent during implementation to continue the growth of the STEM mindset. These opportunities provide educators an opportunity to embrace STEM and motivate them to use the practices in their instruction. To provide this encouragement to educators, administrators can (1) acknowledge teacher leaders in STEM and provide opportunities for others to learn through job-embedded learning, (2) promote collaboration and communication among educators to share their STEM experiences, and (3) trust that teachers are providing students learning opportunities centered around STEM instructional practices. These efforts of providing encouragement are also seen in after implementation.

After implementation. As revealed in the study, each school participating has been implementing STEM innovation for multiple years; therefore, implementation of the innovation does not occur quickly. Hall and Hord (2015) commented that for implementation to become fully operational in the educational setting, 3-5 years is needed; therefore, "change is a process and not an event" (Hall & Hord, 2015, p. 10). After this time frame, constant revisiting and maintenance opportunities are needed to refreeze the organization and develop lasting change (Hussain et al., 2016). Referring back to the Implementation Support Sequence Diagram, after implementation, revisiting the STEM vision and goals occurs. Continuing to revisit these goals every year provides

upkeep of the innovation. Also, these opportunities provide a consistent understanding of the innovation and allow all educators to be part of the change process (Hussain et al., 2016).

In addition to revisiting the school's STEM vision and goals, maintaining communication between community and business partnerships occurs after implementation. Partnerships impact the school and vice versa. They are encouraging students to develop real-world skills (Iowa Governor's STEM Advisory Council, 2017). Maintaining these partnerships enables business and community partners to become part of the classroom environment (Friday Institute for Educational Innovation, 2013).

Additionally, after implementation, administration should revisit professional learning opportunities. Before and during the implementation of STEM, educators participate in continuous professional learning; however, after implementation of the innovation has occurred, continuous efforts to increase understanding of the innovation should transpire. Every year, research is conducted on STEM instructional practices and new methods of incorporating these practices in the classroom are revealed; therefore, opportunities to enhance the learning of STEM education should continue to take place even after the innovation has been implemented.

Furthermore, after implementation of STEM, school administration should continue to offer opportunities for educators to collaborate. As discussed previously in during implementation, these opportunities enable enhanced understanding and offer educators chances to work together through job-embedded learning. Educators, as with any learner, can learn from those involved in the process as well. Providing occasions for educators to work together and discuss perspectives of the STEM innovation allows for

unity and clarity.

Not only should administration continue offering opportunities for educators to collaborate, but they should also continue acquiring funding of the innovation. Materials, STEM lessons, STEM curriculum, and STEM professional learning opportunities enhance STEM education. Materials are required to engage students in the different processes of active learning, and STEM lessons and STEM curriculum can provide educators with additional STEM resources; however, all of these supports require funding. Some funding of the innovation is available at the federal level, though the majority of funding is found in the private sector through state and local grants; therefore, continuing to persist with these applications will enable all educators to benefit.

In addition to continuing efforts to acquire additional funding of STEM education, administration is urged to provide educator encouragement in using STEM innovation. As mentioned previously, STEM requires educators to change their mindset. It also requires them to adapt their traditional practices to ones that are integrated and interdisciplinary. Providing support and encouragement, even after implementation occurs, continues efforts in the refreezing phase of Kurt Lewin's model of organizational change.

Recommendations and Implications for Future Research

Several years ago, President Barack Obama acknowledged science is more than a subject taught in school, elements found on the periodic table, or properties of waves (U.S. Department of Education, n.d.). He described science as "an approach to the world, a critical way to understand and explore and engage with the world, and then have the capacity to change that world and to share this accumulated knowledge" (U.S.

Department of Education, n.d., para. 1). This progressive thinking has led many educational institutions to increase their attention to STEM education; however, more secondary schools are utilizing the innovation, and fewer elementary schools are applying the practices provided by the innovation, even though educators understand the importance of science literacy starting in early childhood (Cafarella et al., 2017; Worth, 2010). Therefore, in progressing forward, research realized in this study necessitates further investigation. During the elementary formative years, students express interest and curiosity. This natural desire for knowledge encourages exploration and a love for learning that will drive elementary students into their secondary years (STEAM Powered Family, 2017); therefore, STEM education is a valuable practice to begin implementation in elementary.

When recommending future research, the researcher proposes different possibilities. One possibility is to replicate this study in other districts to determine if similar results are achieved. Another possibility is to broaden the population sample and include multiple districts in the research, comparing educator perspectives at each district. Also, the researcher proposes focusing research on cultivating STEM professional learning opportunities. Future research involving professional learning opportunities to support elementary educators in their understanding of STEM education and instructional practices is needed to enhance educator knowledge, leading to a culture of STEM understanding at the elementary level. Additionally, with regard to future research to support teachers working to implement STEM at the elementary level, more research involving STEM-based instructional practices needs to be explored.

Regardless of which future direction research undergoes, STEM education is

supported globally and is respected as preparing students to think critically "so that they have the chance to become the innovators, educators, researchers, and leaders who can solve the most pressing challenges facing our nation and our world, both today and tomorrow" (U.S. Department of Education, n.d., para. 3). When implementing the innovation, traditional practices will be tested, new interdisciplinary inquiry-based practices will be explored and utilized, challenges will develop, and strengths will be observed; however, all of these elements will introduce and foster a love of learning that instills passion and drive that is crucial during the elementary years (STEAM Powered Family, 2017). STEM education provides habits that create young scientists and engineers and "remind us that there's always something more to learn, and to try, and to discover, and to imagine—and that it's never too early, or too late to create or discover something new" (Office of the Press Secretary, 2015, para. 4).

Conclusion of Study

Kroeger (2016) considered the elementary institute as the opportune setting to invest in the STEM foundation as elementary students are at the age in which science, technology, engineering, and mathematics combine to play a vital part in the globalization and economic strength of the nation. Furthermore, in the STEM elementary classroom, the active learning approach to discovering sets the foundation for the crucial development of promoting a lifelong passion for learning (STEAM Powered Family, 2017). Preston (2018) believed this passion advances creativity in all students, no matter the level of ability. Moreover, STEAM Powered Family (2017) advocated for implementing STEM innovation in the elementary classroom, citing, "the greatest benefit of STEM is that it fosters that love of learning. Instilling that passion and drive to learn

that is at its most crucial stage during the elementary years" (para. 7). Even though, elementary educators understand the need to inspire students and develop a love of learning, many lack STEM understanding and are uncomfortable implementing the innovation in the classroom (Milgrom-Elcott & Blackwell, 2016); however, many elementary educators are willing to develop a STEM mindset and change their traditional practices to ones devoted to encouraging creativity and innovation, though arriving at this place of dedication takes considerable effort. Educators must first understand STEM innovation and define what it will appear to be for the individual school. Next, leadership members need to develop support for the innovation, encouraging lasting growth and use of the innovation. Along the way, educators will experience successes and challenges in implementing the innovation. How educators choose to focus on the successes and attend to the challenges will determine the realization of STEM education for the educator as well as the student and school.

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Appendix A

Instrumentation and Method of Analysis Matrix

Instrumentation and Method of Analysis Matrix

<table>
<tr><th>Research Question</th><th>Quantitative or Qualitative Data Collection Method</th><th>Tools/Instruments</th><th>Data Collected</th><th>Methods of Analysis</th></tr>
<tr><td rowspan="4">How can elementary educators' perceptions and understandings of the STEM innovation be described?</td><td rowspan="2">Quantitative</td><td>Survey Monkey online elementary teacher survey</td><td>Survey Section 3:

Questions 23-28</td><td>Open-response questions: 23, 25, 26, 27, and 28.
Item responses will be analyzed independently and responses will be categorized. A multiple response percentage frequency will be presented in tabular format.

Multiple response question: 24.
Item 24 will be analyzed using multiple response percentage frequency. Percentage frequency will be presented in tabular format.</td></tr>
<tr><td>Survey Monkey online elementary leadership survey</td><td>Survey Section 3:

Questions 22-27</td><td>Open-response questions: 22, 24, 25, 26, and 27.
Item responses will be analyzed independently and responses will be categorized. A multiple response percentage frequency will be presented in tabular format.

Multiple response question: 23.
Item 23 will be analyzed using multiple response percentage frequency. Percentage frequency will be presented in tabular format.</td></tr>
<tr><td rowspan="2">Qualitative</td><td>Teacher Focus Groups (Appendix D)</td><td rowspan="2">Transcripts from sessions (Questions 1-2) detached open-ended narrative notes</td><td rowspan="2">Coding will be used to integrate qualitative data to support quantitative survey data.</td></tr>
<tr><td>Leadership Focus Groups (Appendix E)</td></tr>
</table>

To what extent are STEM instructional practices being implemented?	Quantitative	Survey Monkey online elementary teacher survey	Survey Section 2: Questions 7-22	Likert scale questions: 7-11, 14-15, and 18-22 will be analyzed independently, and percentage frequency distribution will be presented in a table. A measure of central tendency will use mode. Dichotomous response questions: 12-13 and 16-17 Items will be analyzed using percentage frequency. Percentage frequency will be presented in tabular format.
		Survey Monkey online elementary leadership survey	Survey Section 2: Questions 7-21	Likert scale questions: 7-10, 13-14, and 17-21 will be analyzed independently, and percentage frequency distribution will be presented in a table. A measure of central tendency will use mode. Dichotomous response questions: 11-12 and 15-16 Items will be analyzed using percentage frequency. Percentage frequency will be presented in tabular format.
	Qualitative	Teacher Focus Groups Leadership Focus Groups	Transcripts from sessions (Questions 3-4) detached open-ended narrative notes	Coding will be used to integrate qualitative data to support quantitative survey data.
How do elementary educators characterize successes and challenges in implementing the STEM innovation?	Quantitative	Survey Monkey online elementary teacher survey	Survey Section 4: Questions 29-36	Multiple response questions: 29-31 and 33-35. Items will be analyzed using multiple response percentage frequency. Percentage frequency will be presented in tabular format. Open-response questions: 32 and 36 Item responses will be analyzed independently and responses will be categorized. A multiple response percentage

				frequency will be presented in tabular format. Dichotomous response questions: 31-32. Items will be analyzed using percentage frequency. Percentage frequency will be presented in tabular format.
		Survey Monkey online elementary leadership survey	Survey Section 4: Questions 28-34	Multiple response questions: 28-30 and 32-33. Items will be analyzed using multiple response percentage frequency. Percentage frequency will be presented in tabular format. Open-response questions: 31 and 34 Item responses will be analyzed independently and responses will be categorized. A multiple response percentage frequency will be presented in tabular format. Dichotomous response question: 30. Items will be analyzed using percentage frequency. Percentage frequency will be presented in tabular format.
	Qualitative	Teacher Focus Groups Leadership Focus Groups	Transcripts from sessions (Questions 5-6) detached open-ended narrative notes	Coding will be used to integrate qualitative data to support quantitative survey data.
To what extent are elementary educators supported in their implementation of the STEM innovation?	Quantitative	Survey Monkey online elementary teacher survey	Survey Section 5: Questions 37-47	Dichotomous response questions: 37, 39, 41, 43, and 46. Items will be analyzed using percentage frequency. Percentage frequency will be presented in tabular format. Open-response questions: 38, 40, and 42 Item responses will be analyzed independently and responses will be

				categorized. A multiple response percentage frequency will be presented in tabular format. Multiple response questions: 44, 45, and 47. Items will be analyzed using multiple response percentage frequency. Percentage frequency will be presented in tabular format.
		Survey Monkey online elementary leadership survey	Survey Section 5: Questions 35-46	Dichotomous response questions: 35, 38, and 41. Items will be analyzed using percentage frequency. Percentage frequency will be presented in tabular format. Numerical response questions: 43-45 Item responses will be analyzed independently and responses will be categorized using percentage frequency and will be presented in tabular format. Open-response questions: 36, 37, 39, and 40 Item responses will be analyzed independently and responses will be categorized. A multiple response percentage frequency will be presented in tabular format. Multiple response question: 42 and 46. Item will be analyzed using multiple response percentage frequency. Percentage frequency will be presented in tabular format.
	Qualitative	Teacher Focus Groups	Transcripts from sessions (Question 7) detached open-ended narrative	Coding will be used to integrate qualitative data to support quantitative survey data.

		Leadership Focus Groups	notes	
How could the STEM innovation be further supported in the elementary classroom?	Quantitative	Survey Monkey online elementary teacher survey	Survey Section 6: Questions 48-52	Dichotomous response questions: 48-50. Items will be analyzed using percentage frequency. Percentage frequency will be presented in tabular format. Multiple response question: 51-52. Item will be analyzed using multiple response percentage frequency. Percentage frequency will be presented in tabular format.
		Survey Monkey online elementary leadership survey	Survey Section 6: Questions 47-51	Dichotomous response questions: 47-49. Items will be analyzed using percentage frequency. Percentage frequency will be presented in tabular format. Multiple response question: 50-51. Item will be analyzed using multiple response percentage frequency. Percentage frequency will be presented in tabular format.
	Qualitative	Teacher Focus Groups	Transcripts from sessions (Question 8) detached open-ended narrative notes	Coding will be used to integrate qualitative data to support quantitative survey data.
		Leadership Focus Groups		

Appendix B

Teacher Survey

Teacher Survey

My name is Jodi Witherspoon, and I am a fifth-grade teacher in the district. I am currently a doctoral candidate at Gardner-Webb University and working on my dissertation investigating elementary educator's perspectives in implementing the STEM initiative.

The goal of the survey that follows is to gain your understandings, perceptions, successes, and challenges of implementing the STEM initiative. Currently, there are three schools in the district dedicated to implementing STEM education. Your contribution to this survey is valuable in understanding the implementation process in the elementary setting.

My hope in gaining your perspective on the implementation process will allow other elementary schools to achieve an understanding of the successes, challenges, and support systems needed to encourage the implementation of the STEM initiative in their elementary classroom.

No names or personal information will be used in any context within the study. Your participation in this survey will be voluntary. Therefore, you may skip any question that may cause you discomfort or you many withdraw from the survey at any time without penalty. Additionally, your responses may be removed if you choose.

Once again, thank you for participating in this survey. I appreciate your honesty and willingness to assist in this research. If you have any questions about the survey or research, feel free to contact me at XXXXXX.

Teacher Survey

Section 1: Demographics

1. Are you currently employed as a/n:

   ○ Teacher (Logic-Teacher)

   ○ English Language Learner teacher (Logic-Teacher)

   ○ Exceptional Children teacher (Logic-Teacher)

   ○ Principal (logic-leadership)

   ○ Assistant Principal (logic-leadership)

   ○ Instructional Facilitator (logic-leadership)

2. In what elementary school are you employed?

   ○ Heritage Elementary School

   ○ Old Mountain Elementary School

   ○ Louis Armstrong Elementary School

3. How many years of experience do you have in education?

   ○ 0 years (I am a first-year teacher) (Logic out)

   ○ 1-4 years

   ○ 5-9 years

   ○ 10-14 years

   ○ 15-19 years

   ○ 20-24 years

   ○ 25+ years

4. How many years of experience do you have in this school?

   ○ I am new to the school this school year (Logic out)

   ○ 1-5 years

   ○ 6-10 years

   ○ 11-15 years

   ○ 16-20 years

   ○ 21-25 years

   ○ 25+ years

5. What is the highest-level degree you have obtained?

○ Bachelors'

○ Masters'

○ Masters' + (more than one masters' degree)

○ Doctorate

6. Are you currently working towards an advanced degree, if so what degree?

○ I am not working towards an advanced degree

○ Masters'

○ Masters' + (second or third Masters' Degree)

○ Doctorate

Section 2: STEM Instructional Practices

The following section of the survey focuses on discussions of STEM instructional practices implemented at your school and in your classroom within professional settings (i.e. PLC, faculty meetings, and grade level meetings).

7. In a month's time, how often does your leadership team discuss STEM education?

   ○ Never

   ○ Rarely

   ○ Sometimes

   ○ Usually

   ○ Always

8. In a month's time, how often do teachers discuss STEM education with you?

   ○ Never

   ○ Rarely

   ○ Sometimes

   ○ Usually

   ○ Always

9. How often do you collaborate with other teachers on STEM education?

   ○ Never

   ○ Rarely

   ○ Sometimes

   ○ Usually

   ○ Always

10. In your opinion to what extent do you believe your school has implemented STEM initiative?

   ○ Not at all

   ○ To a small extent

   ○ To some extent

   ○ Almost fully

   ○ To the full extent

11. In your opinion to what extent do you believe you have implemented STEM initiative in your classroom?

○ Not at all

○ To a small extent

○ To some extent

○ Almost Fully

○ To the full extent

12. Have you been introduced to inquiry-based learning (i.e., problem-based learning)?

○ yes

○ no

13. Have other members of your staff been introduced to inquiry-based learning?

○ yes

○ no

14. How often does your school encourage educators to use inquiry-based learning?

○ Never

○ Rarely

○ Sometimes

○ Usually

○ Always

15. How often do you use inquiry-based learning in your classroom?

○ Never

○ Rarely

○ Sometimes

○ Usually

○ Always

16. Have you been introduced to the Engineering Design Process?

    ○ yes

    ○ no

17. Have other members of your staff been introduced to the Engineering Design Process?

    ○ yes

    ○ no

18. How often does your school encourage educators to use the Engineering Design Process?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

19. How often do you use the Engineering Design Process in your classroom?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

20. How often does your school encourage the use of active learning activities involving STEM?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

21. In a month's time, how often do you believe you use active learning activities, involving the STEM initiative, to solve real-world problems?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

22. How often does your school encourage the use of the Next Generation Science Standards?

○ Never

○ Rarely

○ Sometimes

○ Usually

○ Always

Section 3: Perceptions and Understandings of STEM

The following section of the survey focuses on the elementary educators' perceptions and understandings of the STEM initiative. This section asks for you to provide descriptions of your current understanding of STEM education at your school.

23. In your own words describe STEM:

24. In your opinion what are the top three most important reasons to implement STEM initiative in an elementary classroom? (Choose 3)

    ○ student achievement

    ○ student engagement

    ○ integrated learning

    ○ development of higher order thinking skills

    ○ student creativity

    ○ development of 21st-century learning skills

    ○ students learning from their mistakes

25. In your own words define inquiry-based learning (i.e., problem-based learning):

26. In your own words define the Engineering Design Process:

27. In your own words describe active learning:

28. In your own words describe your understanding of the Next Generation Science Standards:

Section 4: Successes and Challenges in Implementation

The following section of the survey involves characterizing successes and challenges in implementing the STEM initiative.

Successes

29. In your opinion what are the top three supports elementary educators need to implement STEM successfully: (Choose 3)

○ STEM understanding

○ STEM preparation in teacher education program

○ professional development

○ funding

○ materials

○ lessons

○ curriculum

○ encouragement

○ Other:____________

30. When you think of the STEM implementation process what did **your leadership team** do to make your implementation successful? (Choose all that apply)

○ applied for grants

○ provided teachers with funding

○ held a fundraiser

○ provided teachers with materials

○ provided teachers with curriculum

○ provided teachers with professional development

○ provided teachers with encouragement

○ Other:____________

31. When you think of the STEM implementation process what did **you** accomplish to help make your implementation successful? (Choose all that apply)

    ○ applied for grants (federal, state, local)

    ○ applied for Donors Choose

    ○ held a fundraiser

    ○ purchased materials

    ○ researched STEM education

    ○ created lessons

    ○ purchased STEM lesson plans

    ○ attended STEM professional development opportunities

    ○ other:___________

32. Describe your successes in implementing STEM initiative:

Challenges

33. When you think of the STEM implementation process what is one thing **your leadership team** could have offered to make your implementation successful? (Choose 1)

○ provided you with funding

○ provided you with materials

○ provided you with a curriculum

○ provided you with quality STEM lessons

○ provided you with an opportunity to construct quality STEM lessons with colleagues

○ provided you with STEM professional development

○ provided you with encouragement

○ other:___________

34. When you think of the STEM implementation process what is one thing **you** could have accomplished to help make your implementation successful? (Choose 1)

○ applied for grants

○ purchased materials

○ researched STEM education

○ created quality STEM lessons

○ created quality STEM lessons with colleagues

○ attended STEM professional development opportunities

○ ask others for help

○ other:___________

35. In your opinion what are the top three most important challenges **you** faced when implementing STEM initiative? (Choose 3)

○ lack of STEM preparation in teacher education program

○ funds were not available

○ materials were expensive

○ access to materials were limited

○ creating lessons were difficult

○ team planning was difficult

○ changing mindset was difficult

○ encouragement to use the STEM initiative was not given

○ encouragement of others to use the STEM initiative is difficult

○ STEM professional development attended was not aligned to the elementary level

○ STEM professional development attended was not helpful

○ other:___________

36. Describe your challenges in implementing STEM initiative:

Section 5: Current Supports Received

The following section of the survey focuses on support received currently during the STEM implementation process. This section is divided into four parts. The four parts focus on funding, changing mindsets, resources, and professional development.

The following part of the survey deals with **funding** involved in implementing STEM innovation.

37. Has your school received funds for implementing STEM initiative? (logic)

    ○ yes

    ○ no

38. How were those funds used?

The following part of the survey deals with the **growth mindset** of those involved in implementing STEM initiative. A growth mindset is one in which the individual understands their ability to gain knowledge, involving a concept (STEM), can be developed through determination, good practice, and persistence.

39. Did you feel supported by school leaders through the implementation process? (logic)

    ○ yes

    ○ no

40. How have your school leaders supported you through the implementation process?

41. Did you feel supported by other teachers through the implementation process? (logic)

    ○ yes

    ○ no

42. How have other teachers supported you through the implementation process?

The following part of the survey deals with **resources** needed in implementing STEM initiative. Resources are defined as strategies used to support or enhance the quality of implementation.

43. In your opinion do you believe you have sufficient access to STEM resources? (Choose 1)

○ I believe have full access

○ I believe have some access

○ I believe have limited access

○ I believe have no access

44. From where did you obtain the materials needed to educate students in using STEM initiative? (Choose all that apply)

○ I purchased the materials myself

○ The school purchased the materials

○ My grade level purchased the materials

○ Other teachers donated the materials

○ My students donated the materials

○ Community members donated the materials

○ Area businesses donated the materials

○ other:___________

45. What resources has your school provided to make STEM initiative successful in your classroom? (Choose all that apply)

○ STEM professional development

○ supplies

○ STEM lessons

○ STEM curriculum

○ planning time for STEM

○ collaborative planning time for STEM

○ funding for STEM

○ Help with STEM questions

○ other:___________

The following part of the survey deals with the **professional development** needed in implementing STEM initiative.

46. How many school offered STEM professional development sessions have you attended? (Choose 1)

○ All of them

○ Some of them

○ none of them

47. What STEM professional development opportunities have you received? (Choose all that apply)

○ inquiry-based learning

○ engineering design process

○ active learning

○ design of real-world problems

○ STEM lesson design

○ integration of STEM into multiple subjects

○ building of 21st-century skills

○ other:___________

Section 6: Future Supports Needed

The following section of the survey describes how the STEM initiative could be **supported further** in the elementary classroom. This section is divided into four parts. The four parts focus on funding, changing mindsets, resources, and professional development.

The following part of the survey deals with the need for **further funding** of the STEM initiative.

48. Now that the STEM initiative is continuing to be implemented what is one thing you could work towards to increase funding for STEM in your classroom? (choose 1)

    ○ apply for grants (federal, state, local)

    ○ ask community businesses for funds

    ○ ask community leaders for funds

    ○ ask parents for funds in newsletters

    ○ hold a classroom fundraiser

    ○ complete a Donors Choose

    ○ other: _____________

The following part of the survey deals with how the **growth mindset** could be **further supported** in the elementary classroom. A growth mindset is one in which the individual understands their ability to gain knowledge, involving a concept (STEM), can be developed through determination, good practice, and persistence.

49. Now that the STEM initiative is continuing to be implemented what is one thing school leaders could do to support further mindset growth? (choose 1)

    ○ focus only on the STEM initiative

    ○ model the STEM mindset

    ○ provide feedback on STEM lessons

    ○ provide further STEM professional development

    ○ provide encouragement

    ○ embrace the word "yet" (We are not there yet, but…)

    ○ other: _____________

50. Now that the STEM initiative has been implemented what is one thing **you** could do to support your further mindset growth? (Choose 1)

    ○ focus only on the STEM initiative

    ○ model the STEM mindset

    ○ ask for feedback on STEM lessons

    ○ attend further STEM professional development

    ○ value positive STEM experiences

    ○ embrace the word "yet" (I am not there yet, but…)

    ○ persist when things get tough

    ○ other: _____________

The following part of the survey deals with the **further resources** needed to support future implementation of the STEM initiative. Resources are defined as strategies used to support or enhance the quality of implementation.

51. What additional resources do you need for further successful implementation of the STEM initiative? (Choose all that apply)

○ additional STEM professional development opportunities

○ opportunities to visit successfully implemented STEM classrooms in my school

○ opportunities to visit successfully implemented STEM schools

○ access to lessons

○ access to a curriculum

○ access to funds

○ other: _____________

The following part of the survey deals with **further professional development** needed to support future the elementary classroom in implementing the STEM initiative.

52. What further professional development experiences would help you successfully implement the STEM initiative? (Choose all that apply)

○ professional development involving the engineering design process

○ professional development involving active learning

○ professional development involving inquiry-based learning

○ professional development involving the creation of real-world problems

○ other: _____________

53. A teacher focus group session will be held after school hours to gain teacher understandings and perspectives of implementing the STEM initiative at your school. (logic)

○ No, I am not interested in participating in the teacher focus group at my school.

○ Yes, I am interested in participating in the teacher focus group at my school.

Appendix C

School Leadership Survey

Leadership Survey

My name is Jodi Witherspoon, and I am a fifth-grade teacher in the district. I am currently a doctoral candidate at Gardner-Webb University and working on my dissertation investigating elementary educator's perspectives in implementing the STEM initiative.

The goal of the survey that follows is to gain your understandings, perceptions, successes, and challenges of implementing the STEM innovation. Currently, there are three schools in the district area dedicated to implementing STEM education. Your contribution to this survey is valuable in understanding the implementation process in the elementary setting.

My hope in gaining your perspective on the implementation process will allow other elementary schools to achieve an understanding of the successes, challenges, and support systems needed to encourage the STEM initiative in the elementary classroom.

No names or personal information will be used in any context within the study. Your participation in this survey will be voluntary. Therefore, you may skip any question that may cause you discomfort or you many withdraw from the survey at any time without penalty. Additionally, your responses may be removed if you choose.

Once again, thank you for participating in this survey. I appreciate your honesty and willingness to assist in this research. If you have any questions about the survey or research, feel free to contact me at XXXXXX.

School Leadership Survey

Section 1: Demographics

1. Are you currently employed as a/n:

   ○ Teacher (Logic-Teacher)

   ○ English Language Learner teacher (Logic-Teacher)

   ○ Exceptional Children teacher (Logic-Teacher)

   ○ Principal (logic-leadership)

   ○ Assistant Principal (logic-leadership)

   ○ Instructional Facilitator (logic-leadership)

2. In what elementary school where you employed during the 2017-2018 school year?

   ○ Heritage Elementary School

   ○ Old Mountain Elementary School

   ○ Louis Armstrong Elementary School

   ○ Other (Logic Out)

3. As of the 2017-2018 school year, how many years of experience have you had in education?

   ○ 1-4 years

   ○ 5-9 years

   ○ 10-14 years

   ○ 15-19 years

   ○ 20-24 years

   ○ 25+ years

4. As of the 2017-2018 school year, how many years of experience had you had in that school?

   ○ 1-5 years

   ○ 6-10 years

   ○ 11-15 years

   ○ 16-20 years

   ○ 21-25 years

   ○ 25+ years

5. What is the highest-level degree you have obtained?

○ Bachelors'

○ Masters'

○ Masters' + (more than one masters' degree)

○ Doctorate

6. Are you currently working towards an advanced degree, if so what degree?

○ I am not working towards an advanced degree

○ Masters'

○ Masters' + (second or third Masters' Degree)

○ Doctorate

Section 2: STEM Instructional Practices

The following section of the survey focuses on discussions of STEM instructional practices implementated at your school within professional settings (i.e. PLC, faculty meetings, and grade level meetings).

7. In a month's time, how often does your leadership team discuss STEM education with teachers?

   ○ Never

   ○ Rarely

   ○ Sometimes

   ○ Usually

   ○ Always

8. In a month's time, how often do teachers discuss STEM education with a member of the school's leadership team?

   ○ Never

   ○ Rarely

   ○ Sometimes

   ○ Usually

   ○ Always

9. In your opinion to what extent do you believe your school has implemented the STEM initiative?

   ○Not at all

   ○ To a small extent

   ○ To some extent

   ○ Almost fully

   ○ To the full extent

10. In your opinion to what extent have you observed the STEM initiative being used in classrooms?

   ○Not at all

   ○ To a small extent

   ○ To some extent

   ○ Almost fully

   ○ To the full extent

11. Have you been introduced to inquiry-based learning (i.e., problem-based learning)?

    ○ yes

    ○ no

12. Have members of your staff been introduced to inquiry-based learning?

    ○ yes

    ○ no

13. How often does your leadership team encourage educators to use inquiry-based learning?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

14. How often have you observed the use of inquiry-based learning in classrooms?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

15. Have you been introduced to the Engineering-Design Process?

    ○ yes

    ○ no

16. Have members of your staff been introduced to the Engineering-Design Process?

    ○ yes

    ○ no

17. How often does your leadership team encourage educators to use the Engineering Design Process?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

18. How often have you observed the use of the Engineering Design Process in classrooms?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

19. How often does your leadership team encourage the use of active learning activities involving STEM?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

20. How often have you observed classrooms using active learning activities to solve real-world problems?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

21. How often does your leadership team encourage the use of the Next Generation Science Standards?

    ○ Never

    ○ Rarely

    ○ Sometimes

    ○ Usually

    ○ Always

Section 3: Perceptions and Understandings of STEM

The following section focuses on the elementary educators' perceptions and understandings of the STEM initiative. This section asks for you to provide descriptions of your current understanding of STEM education at your school.

22. In your own words describe STEM:

23. In your opinion what are the top three most important reasons to implement the STEM initiative in the elementary classroom? (Choose 3)

   ○ student achievement

   ○ student engagement

   ○ integrated learning

   ○ development of higher order thinking skills

   ○ student creativity

   ○ development of 21st-century learning skills

   ○ students learning from their mistakes

24. In your own words define inquiry-based learning (i.e. problem-based learning):

25. In your own words define the Engineering Design Process:

26. In your own words describe active learning:

27. In your own words describe your understanding of the Next Generation Science Standards:

Section 4: Successes and Challenges in Implementation

The following section of the survey involves characterizing successes and challenges in implementing the STEM initiative.

Successes

28. In your opinion what are the top three supports elementary educators need to implement STEM successfully: (Choose 3)

    ○ STEM understanding

    ○ STEM preparation in teacher education program

    ○ professional development

    ○ funding

    ○ materials

    ○ lessons

    ○ curriculum

    ○ encouragement

    ○ other: _____________

29. When you think of the STEM implementation process what did **your leadership team** do to help make teachers implementation successful? (Choose all that apply)

    ○ applied for grants

    ○ provided teachers funding

    ○ held a fundraiser

    ○ provided teachers materials

    ○ provided teachers a STEM curriculum

    ○ provided teachers STEM professional development

    ○ provided teachers encouragement

    ○ other: _____________

30. When you think of the STEM implementation process what did **you** do to help make teachers implementation successful? (Choose all that apply)

    ○ applied for grants (federal, state, local)

    ○ provided teachers funding

    ○ held a fundraiser

    ○ provided teachers materials

    ○ researched STEM education

    ○ provided teachers a curriculum

    ○ provided teachers STEM professional development

    ○ provided teachers encouragement

    ○ other: _____________

31. Describe your leadership’s team successes in helping your teachers implement the STEM initiative:

Challenges

32. When you think of the STEM implementation process what is one thing **your leadership team** could have offered to make teacher implementation successful? (Choose 1)

    ○ provided teachers funding

    ○ provided teachers materials

    ○ provided teachers a curriculum

    ○ provided teachers quality STEM lessons

    ○ provided teachers an opportunity to construct quality STEM lessons with colleagues

    ○ provided teachers STEM professional development

    ○ provided teachers encouragement

    ○ other: ______________

33. In your opinion what are the top three most important challenges elementary educators face when implementing the STEM initiative? (Choose 3)

    ○ lack of STEM preparation in teacher education program

    ○ funds are not available

    ○ materials are expensive

    ○ access to materials is limited

    ○ creating lessons is difficult

    ○ team planning is difficult

    ○ changing mindset is difficult

    ○ encouragement to use the STEM initiative is not given

    ○ STEM professional development is not aligned to the elementary level

    ○ STEM professional development is not helpful

    ○ other: ______________

34. Describe your leadership's team challenges in helping your teachers implement the STEM initiative:

Section 5: Current Supports Received

The following section of the survey focuses on support received currently during the STEM implementation process. This section is divided into four parts. The four parts focus on funding, changing mindsets, resources, and professional development.

The following part of the survey deals with **funding** involved in implementing the STEM initiative.

35. Has your school received funds to implement the STEM initiative? (logic)

    ○ yes

    ○ no

36. How were those funds used?

37. From where were funds received?

The following part of the survey deals with the **growth mindset** of those involved in implementing the STEM initiative. A growth mindset is one in which the individual understands their ability to gain knowledge involving a concept (STEM) can be developed through determination, good practice, and persistence.

38. Did you feel supported by district leaders through the implementation process? (logic)

    ○ yes

    ○ no

39. How have your district leaders supported you through the implementation process?

40. How have school leaders supported teachers' growth mindsets through the implementation process?

The following part of the survey deals with **resources** needed in implementing the STEM initiative. Resources are defined as strategies used to support or enhance the quality of implementation.

41. In your opinion do you believe teachers have sufficient access to STEM resources? (Choose 1)

○ I believe teachers have full access

○ I believe teachers have some access

○ I believe teachers have limited access

○ I believe teachers have no access

42. What resources has your school provided to make the STEM initiative successful in teachers' classroom? (Choose all that apply)

○ STEM professional development

○ supplies

○ STEM lessons

○ STEM curriculum

○ planning time for STEM

○ collaborative planning time for STEM

○ funding for STEM

○ help with STEM questions

○ other: _______________

The following part of the survey deals with the **professional development** needed in implementing the STEM initiative.

43. How many professional development sessions did your school have during the 2017-2018 school year? (write the total number of **all** professional development sessions)

    ____

44. How many STEM professional development sessions did your school have during the 2017-2018 school year? (write the total number of **STEM** professional development sessions)

    ____

45. How many professional development sessions involving STEM did you attend as a school leader? (write the number)

    ____

46. What STEM professional development opportunities have you received? (Choose all that apply):

    ○ inquiry-based learning

    ○ engineering design process

    ○ active learning

    ○ design of real-world problems

    ○ STEM lesson design

    ○ integration of STEM into multiple subjects

    ○ building of 21st-century skills

    ○ other: _______________

Section 6: Future Supports Needed

The following section of the survey describes how the STEM initiative could be **supported further** in the elementary classroom. This section is divided into four parts. The four parts focus on funding, changing mindsets, resources, and professional development.

The following part of the survey deals with the need for further **funding** of the STEM initiative.

47. Now that the STEM initiative is continuing to be implemented what is one thing you could work towards to increase funding for STEM? (choose 1)

○ apply for grants (federal, state, local)

○ ask community businesses for funds

○ ask community leaders for funds

○ ask parents for funds in newsletters

○ hold a fundraiser

○ other: _______________

The following part of the survey deals with how the **growth mindset** could be **further supported** in the elementary classroom. A growth mindset is one in which the individual understands their ability to gain knowledge involving a concept (STEM) can be developed through determination, good practice, and persistence.

48. Now that the STEM initiative is continuing to be implemented what is one thing **school leaders** could do to support further mindset growth? (choose 1)

○ focus only on the STEM initiative

○ model the STEM mindset

○ provide feedback on STEM lessons

○ provide further STEM professional development

○ provide encouragement

○ embrace the word "yet" (We are not there yet, but…)

○ other: _______________

49. Now that the STEM initiative has been implemented what is one thing **you** could do to support further mindset growth? (Choose 1)

○ focus only on the STEM initiative

○ model the STEM mindset

○ provide feedback on STEM lessons

○ attend further STEM professional development

○ value positive STEM experiences

○ embrace the word "yet" (We are not there yet, but…)

○ persist when things get tough

○ other: _______________

The following part of the survey deals with the **further resources** needed to support future implementation of the STEM initiative. Resources are defined as strategies used to support or enhance the quality of implementation.

50. What additional resources do your teachers need for further successful implementation of the STEM initiative? (Choose all that apply)

○ additional STEM professional development opportunities

○ opportunities to visit successfully implemented STEM classrooms in my school

○ opportunities to visit successfully implemented STEM schools

○ access to lessons

○ access to a curriculum

○ access to funds

○ other: _______________

The following part of the survey deals with the **professional development** needed in further supporting the elementary classroom in implementing the STEM initiative.

51. What further professional development experiences would help your teachers successfully implement the STEM initiative? (Choose all that apply)

○ professional development involving the engineering design process

○ professional development involving active learning

○ professional development involving inquiry-based learning

○ professional development involving the creation of real-world problems

○ other: _______________

52. A leadership focus group session will be held after school hours to gain school leaders understandings and perspectives of implementing the STEM initiative at your school. (logic)

○ No, I am not interested in participating in the leadership focus group.

○ Yes, I am interested in participating in the leadership focus group.

Appendix D

Focus Group Interview Protocol for Teachers

Focus Group Interview Protocol (Teacher)

Date:
Place:
Interviewer: Jodi Witherspoon
Interviewees:

Introduction:

Hello everyone, my name is Jodi Witherspoon, and this is _____________ (name of observer and note taker). I am a doctoral candidate at Gardner-Webb University, as well as a fifth-grade teacher at Heritage Elementary. I will be conducting this focus group session and ________________ (name of observer and note taker) will be an observer and will take notes during the session. I invited you all here to discuss your understandings, perceptions, successes, and challenges of implementing the STEM initiative and how this change in practice has impacted you. Your opinions and views are very important to me, so I want you to feel comfortable to express yourself freely during our discussions. There are no right and wrong answers. Therefore, I ask everyone to respect the privacy of other members and not discuss anything said within the confines of this focus group session.

This conversation will be recorded and then transcribed and will be used for research purposes only. _____________ (transcriber), my transcriber, and I will be the only ones to listen to the tape. No names or personal information will be used in any context in the study. Your participation in this focus group session will be voluntary. You may withdraw from the focus group session at any time without penalty by telling me you would like to withdraw from the session and then leave the room. I then can remove your responses from the research if you so choose. Are there any questions?

Some practical issues to discuss: the discussion will last for about one hour. I will be asking you questions as we go along and if you need clarification feel free to ask. This session is designed so everyone can express his or her viewpoints, however, in our limited time, I might move us along so everyone can have a chance to voice their views. I ask everyone to please give each other the chance to express their opinion during the conversation. Additionally, you can address each other when expressing your opinion; I am only here to assist in the discussion. Is everything clear about the course of the focus group discussion? Are there any questions?

Questions	Notes
1. STEM education has different meanings to different people. How would you describe your understanding of STEM education? Question 1 (Understandings)	
2. Many secondary schools are implementing the STEM initiative. However, fewer elementary schools are proposing implementing the initiative. Why do you think elementary schools should implement the STEM initiative? Question 1 (Perceptions)	
3. STEM requires educators to change their instructional practices. Describe how you prepared to change your traditional instructional practices to practices that support STEM education (i.e., inquiry-based learning, engineering design process, active learning, Next Generation Science Standards). Question 2 (Instructional Practices)	
4. Talk about how you are implementing the STEM initiative in your classroom. Question 2 (Instructional Practices)	

Questions	Notes
5. Describe your successes in implementing STEM. Question 3 (Successes)	
6. Describe your challenges in implementing STEM. Question 3 (Challenges)	
7. Describe supports you received that encouraged you to transition your traditional instructional practices to ones that support STEM education (i.e., inquiry-based learning, engineering design process, active learning, Next Generation Science Standards). Question 4 (Current Support)	
8. Explain how STEM could be further supported in your elementary classroom. • Explain what you could do to support STEM education further. • Explain what your leadership team could do to support STEM education further. Question 5 (Future Support)	

Appendix E

Focus Group Interview Protocol for School Leaders

Focus Group Interview Protocol (School Leaders)

Date:
Place:
Interviewer: Jodi Witherspoon
Interviewees:

Introduction:

Hello everyone, my name is Jodi Witherspoon, and this is _____________ (name of observer and note taker). I am a doctoral candidate at Gardner-Webb University, as well as a fifth-grade teacher at Heritage Elementary. I will be conducting this focus group session and ________________ (name of observer and note taker) will be an observer and will take notes during the session. I invited you all here to discuss your understandings, perceptions, successes, and challenges of implementing the STEM initiative and how this change in practice has impacted you. Your opinions and views are very important to me, so I want you to feel comfortable to express yourself freely during our discussions. There are no right and wrong answers. Therefore, I ask everyone to respect the privacy of other members and not discuss anything said within the confines of this focus group session.

This conversation will be recorded and then transcribed and will be used for research purposes only. _____________ (transcriber), my transcriber, and I will be the only ones to listen to the tape. No names or personal information will be used in any context in the study. Your participation in this focus group session will be voluntary. You may withdraw from the focus group session at any time without penalty by telling me you would like to withdraw from the session and then leave the room. I then can remove your responses from the research if you so choose. Are there any questions?

Some practical issues to discuss: the discussion will last for about one hour. I will be asking you questions as we go along and if you need clarification feel free to ask. This session is designed so everyone can express his or her viewpoints, however, in our limited time, I might move us along so everyone can have a chance to voice their views. I ask everyone to please give each other the chance to express their opinion during the conversation. Additionally, you can address each other when expressing your opinion; I am only here to assist in the discussion. Is everything clear about the course of the focus group discussion? Are there any questions?

Questions	Notes
1. STEM education has different meanings to different people. How would you describe your understanding of STEM education? Question 1 (Understandings)	
2. Many secondary schools are implementing the STEM initiative. However, fewer elementary schools are proposing implementing the initiative. Why do you think elementary schools should implement the STEM initiative? Question 1 (Perceptions)	
3. STEM requires educators to change their instructional practices. Describe how your leadership team prepared teachers to change their traditional instructional practices to practices that support STEM education (i.e., inquiry-based learning, engineering design process, active learning, Next Generation Science Standards). Question 2 (Instructional Practices)	
4. Talk about how your school is implementing the STEM initiative. Question 2 (Instructional Practices)	

Questions	**Notes**
5. Describe what your leadership team accomplished to encourage teachers to implement STEM successfully. Question 3 (Successes)	
6. Describe the challenges you noticed when encouraging teachers to implement STEM. Question 3 (Challenges)	
7. Describe the supports your school received that encouraged teachers to transition instructional practices to ones that support STEM education (i.e., inquiry-based learning, engineering design process, active learning, Next Generation Science Standards) Question 4 (Current Support)	
8. Explain how STEM could be further supported in your school. Question 5 (Future Support)	