SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM): ITS INFLUENCE ON STUDENT PERFORMANCE IN CORE CONTENT AREAS

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Abstract

Students are expected to demonstrate an acute knowledge in the sciences, technology, engineering, and mathematics fields to compete in the global economy. STEM education is at the forefront of many curricular design decisions in districts across the nation. As the need to compete internationally becomes a present and looming responsibility of teachers, finding the appropriate platform for these skills to be taught is imperative for students. The researcher conducted interviews and a focus group with educators regarding the development of student thinking through the STEM focus. The researcher was able to determine the integration of STEM into content areas is significant for developing critical thinking skills, enhancing creativity, and maintaining student engagement and perseverance. Further research is needed to develop measures of how STEM influences curricular efficacy, student gains, and teacher preparedness to educate students in the universal landscape of education.
Dedication

I would like to dedicate this dissertation to my late sister, Sonia Renee Hill and my late Aunt, Rosa Marie Shotwell. Sonia was a big sister who taught me to be great, to be accepting, to defend those I love, and just to be as you were created. My Aunt Rose was one of my greatest supporters who believed in me until the end. This dissertation is the culmination of all that they have wished and prayed for in my life. I pray that in heaven they can see and feel what their encouragement has done for their little sister and niece.
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Finally, I would like to use this mantle to acknowledge women who have dedicated themselves to education in the STEM fields. It is with your perseverance that I can exist and thrive in the field of STEM education. Your dedication to moving women, minorities and our nation forward are greatly appreciated.
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CHAPTER I

Introduction and Background

In the United States, the science, technology, engineering and mathematics (STEM) education movement began approximately two decades ago, with one of the first explicit uses of STEM beginning in 2005 (Burrows A. L., 2018). The inception of STEM was the result of the National Science Foundation and the reactive response by the U.S. government to the nations deposition in superiority among the world’s nations (Blackley, 2015). The launching of Sputnik by the Soviet Union in 1957 was perceived by many to be a failure of the United States, “While American schoolchildren were learning how to get along with their peers or how to bake a cherry pie…Soviet children were being steeped in the hard sciences and mathematics needed to win the technology race” (Burrows A. L., 2018).

The rapid development of science has increased the need for individuals who are well equipped in their fields and can add innovation (Yildirm, 2016). STEM education has a positive impact on the academic performance of students in all subject areas (Yildirm, 2016). In previous studies, Becker and Parker (2011) provided a preliminary meta-analysis indicating that integrative approaches among STEM subjects made STEM instruction more effective. This trend, also seen in the integrative approaches, showed a high effect at the elementary school level.

Elementary school teachers could consider incorporating integrative approaches among STEM subjects into their instruction. However, integrative approaches among STEM subjects are still effective at the secondary and college level. As the world continues to evolve there is a need to have an educational approach that mirrors the advancements, creative narratives, and
technological development. With these changes, there has been a swift effort to advance and provide more STEM education opportunities.

Although the STEM acronym represents science, technology, engineering, and mathematics, the field represents a more comprehensive area of subjects than just the core competencies of this economy (Jayarajah, 2014). Therefore, the actual application of STEM may provide students with a productive academic career.

Although the STEM acronym is coined up as the first letters of science, technology, engineering and mathematics, several researchers believed that STEM covers a larger and more comprehensive understanding then these individual disciplines (Yildirim, 2016). STEM philosophy ensures that countries, in which it is applied, maintains their current economic and technological leaderships. On the other hand, it is also used to increase countries success in international examinations such as PISA and TIMSS. These examinations are considered as podiums on which countries place themselves in the race toward global leadership. Thus, solidifying the importance of STEM educational and career opportunities in countries (Yildirim, 2016).

In the twentieth century, there was a noticeable decrease in the number of students who were equipped to handle careers that require mastery of core academic subjects. Educators in the United States saw a significant drop in student performance at grade level in reading and mathematics by the 8th grade. The effectiveness of a country’s educational system plays a crucial role in establishing competitive advantages in the growing global economy (Kereluik, 2013). There have been national efforts to correct this trend through the No Child Left Behind Act and Every Student Succeeds Act. STEM has also become a measure or indicator of school success
and provides comparative data on student performance in critical academic areas across the globe.

The state of Maryland researched the preparedness of STEM workers and the STEM-related disconnect between those responsible for preparing STEM workers academically (Zheng, 2016). Although the state and the nation are producing more STEM majors, there is not a proportional number of STEM-related careers. Education in these fields also coincides with the lack of adequately trained or certified educators who are prepared to train students in STEM education.

As nations individually focus on making their students prepared for the 21st century, there are skills that extend beyond the context of STEM that also need to be developed. Institutions of higher education have a significant responsibility in this race by providing undergraduate education, run teacher training programs, and present in-service training for K-12 teachers (Ahmed, 2016). This becomes a difficult task when students enter these institutions lacking specific foundational skills for success.

From the international standpoint, the need for STEM to be an investment at all levels of education is imperative. For example, Egypt has begun to develop a strategic roadmap to STEM education that will nurture the pipeline of STEM students and to ensure that Egypt has enough talent to meet the requirements of its economic development (Ahmed, 2016).

**Statement of the Problem**

This 21st century is a timeframe where innovations and changes affect societies to a great extent. In line with the characteristic of this time frame, it is expected for individuals who constitute societies to have some competences about information and skills (Zoriu, 2017). Science, technology, engineering and mathematics (STEM) is a major emphasis in global
initiatives seeking to enhance economic prosperity via a highly-educated workforce. As such, many countries have made significant investments in STEM educational initiatives largely driven by concerns about potential shortfalls in STEM qualified professionals in the future (McDonald, 2016). To meet the needs of a rapidly evolving economy, students must be instructed to master STEM content, become innovative, and have command of skills that are relevant for the 21st century workforce. However, studies and literature available to understand STEM education, implementation, and overall academic impact of STEM are limited.

STEM is a politically charged response to global competition and there is a disenchantment in attitudes toward its benefit as a viable pedagogical tool. The struggle to enact a STEM agenda, particularly in primary schools, has not been successful as to teachers defaulting to STEM being a notion instead of an application form of progressive education (Blackley, 2015). Educators often struggle with understanding how to instruct the four content areas. When deconstructed, the following struggles still exist in the instruction of engineering in the classroom as educators attempt to engage students. Engineering has minimal evidence of preparation in primary and middle school, outside of some hands-on project-based learning opportunities, or have preservice teachers that have received training to guide an engineering “experience” adequately (Blackley, 2015). Technology often has various meanings and is loosely interpreted by educators, administrators and other instructional leaders, thus creating confusion on how to instruct technology (Williams, 2011).

Implementing STEM has been an issue at the primary level because most primary school educators were not sufficiently trained or have a minimal confidence to teach science or math (Ross, 2011). These educators have historically shown a preference for teaching literacy, which impedes the instruction of mathematics and science at the lower levels. Finally, science-trained
secondary school teachers, timetabled onto lower secondary classes, were teaching ‘out-of-field’
(e.g., they may be trained as Health & Physical Education specialists, yet are required to prepare
Year 8 mathematics) (Office of the Chief Scientist, 2013). The amount of teaching out-of-field in
science and math was exceptionally high in Australia by comparison with other countries
(Marginson, 2013)

STEM implementation has proven to be difficult. A crucial aspect was the retention of
students from various backgrounds in STEM education. Attrition of students, specifically women
and other minorities in STEM subjects, has been of keen interest during the insurgence of the
initiative. The National Science Foundation invested an estimated $1.5 billion to increase the
number of minorities participating in the sciences (Arcidiacono, 2016). The rate at which
minorities and women engage in the STEM careers is dependent upon the diversity and
interaction of minority students in STEM fields in their formative years in education.

Another crucial aspect was the ability to measure performance of students, in other content
areas. Performance, ability to apply knowledge and see the interdisciplinary connection between
subjects, is a concept that lacks thorough study. In the speedily expanding field of STEM
education, much of the related published academic literature focused upon pedagogical methods
and effective practices instead of long-term strategic directions and future directions of STEM
education as a driver of innovation economy (Ahmed, 2016).

The United States performance and the performance of other nations is keenly dependent
on the preparations of students in STEM fields. PISA test scores did not bring great news about
the American education system, as the United States continues to hover around the international
mean for reading and science literacy. The U.S. still scores below the top performers on these
tests when compared to economically developed countries in Europe and Asia (Serino, 2017).
Significance of Study

This study focused on educator observations of how implementing STEM culture impacts the abilities of students across varied groups and influences students’ engagement in different content areas. The study specifically examines the need for innovation as a leading point for educators to engage all students beginning as early as middle school. The research encapsulated the pedagogical context of STEM and how facilitators engage with the content (Blackley, 2015).

The need for individuals with the prerequisite skills for the 21st century relies on attaining the proper educational background in STEM. Pearl (2017) brought attention to the attrition rates of students at the post-secondary level have been linked to the lack of the exposure to the career possibilities in the STEM fields at an early enough age, and therefore lack the information needed to consider a career in a STEM field. Qualitative information including teacher interviews, curriculum analysis (including a focus group) was analyzed to determine the context and implementation of STEM and its impact on student performance and thinking.

Krajcik (2017) provided an idea of how the broad spectrum of the National Science Foundation’s five core principles of STEM education was being understood and applied to provide an adequate STEM education. Examining how educators were processing these of these five principles was essential to creating the innovators of tomorrow. This, in turn, ensures that all students have equal access to knowledge through experience, have necessary skills living up to the STEM acronym, and the ability to use these skills to progress their understanding.

The purpose of this study was to determine the influence of STEM education as a platform to instruct students across content areas. How does STEM provide various subject matters with the curricular content to prepare students for college and careers? Using interviews and focus groups allowed the researcher to determine how STEM changes educator and student
perspectives of learning. This research documented how educators view the need for funding in these areas. As districts move toward instructing, planning, and building understanding how STEM influence is important when making curricular decisions.

Specialty STEM schools have been present since the earlier portion of this century, having specific focus and goals. These schools have typically built their successes around rigorous academics, problem solving, and application (McDonald, 2016). The researcher hypothesized that this framework allowed for more cognitive development and provided a seamless transition from one skill set to the next. A link between the specific transition from one content area to the next as a hallmark of this study. In the end, the research provided insight to answer the questions surrounding the importance of STEM, its direct influence on academics, and how its framework can be measured by educators through curriculum development.

**Theoretical Framework**

The theoretical framework for this study was Burner theory of discovery learning. In 1964, Burner developed the theory that children’s learning is not rooted in traditional content delivery, but through investigating essential outcomes of learning that include not just the concepts, categories, and problem-solving procedures invented previously by the culture, but by the ability to "invent" these things for oneself (McLeod, 2012).

STEM has been perceived by teachers to, in some cases, prepare students for the multimodal career world in which they live. Data collected by Erdogan (2017), suggested that educators attribute development of student psychomotor and mental skills to STEM education. Educators, mainly pre-service educators, noted the increased opportunity for STEM to assist their educational practices by improving their students’ imagination, handcrafting skills, observation skills, designing skills, engineering skills and high-level thinking skills.
**Research Question**

The essential research question used the teachers as the lens of observation:

What are the designated differences educators, who have experience in traditional education settings, see when STEM is incorporated as the basis for learning?

- How do students think differently?
- What is the progression in thinking when compared to traditional schools?

**Hypotheses**

(a) A benefit of STEM education is its seamless connection to other content areas.

(b) The platform of STEM allows every student an access point to the knowledge.

(c) Students develop critical thinking skills that are transferable across content.

(d) Educators can use STEM to facilitate connections to learning in all subjects.

(e) Student inquiry skills will be enhanced thus improving their performance in other content areas.

**The Researcher**

The researcher, a science educator and STEAM innovator, works in an urban school district. The researcher taught for eight years as a science, math and STEM educator and spent a year working with the Discovery Education network to help develop instructional opportunities for students to enhance their academic skills using STEM as the focus. The desire of this research was to provide an avenue for educators in developing cross-sections of STEM’s four core principles, such as inquiry, design and questioning in all content areas. The researcher holds the belief that preparing 21st century learners is done by acknowledging STEMs place in students’ academic experiences. Not only is preparation an expectation but teachers are properly prepared to carry out the responsibility of teaching with STEM.
Limitations and Delimitations

A limitation to this study was that interviews were conducted in schools that have STEM programs, STEM/STEAM courses or stand-alone STEM classes. Data regarding STEM influence on students’ transferable abilities focused on student comprehension and fluency with informational text, since this is dominate in STEM and related fields. This limited focus on student growth in other subject areas such as ELA and the Social Sciences can provide a narrow view of students using skills constructively across content versus silo use of skills. Other limitations were the frequency that students encounter STEM in the buildings with dedicated STEM classes, as the schedule may only permit one grade level to attend the class.

Delimitations of this were the selection of schools and educators. There were several STEM specialized schools in the southeastern region of the United States. Selection of the schools for this study were based on history with STEM curriculum and distance from the researcher. Also, the focus groups had to experience teaching in schools with STEM programs, coursework and schools without these programs.

Assumptions and Definitions of Terms

Assessments - In education, the term assessment refers to the wide variety of methods or tools that educators use to evaluate, measure, and document the academic readiness, learning progress, skill acquisition, or educational needs of students (Education Reform Glossary, 2015).

CTE (Career Technical Education) - Provides students of all ages with the academic and technical skills, knowledge and training necessary to succeed in future careers and to become lifelong learners (Advance CTE: State Leaders Connecting Learning to Work, 2017).

Culture - The act of developing the intellectual and moral faculties, especially by education (Merriam-Webster 2017).
Core academic subjects-"The term 'core academic subjects' means English, reading or language arts, mathematics, science, foreign languages, civics and government, economics, arts, history, and geography” (107th Congress of the United States, 2002, p. 195).

Cross Curricular- refers to competencies that do not pertain to the content of one or more subjects, but that can be taught, practiced and applied in it, such as learning to learn and social skills (Aslan, 2016).

Self-Efficacy- Student perceptions of their abilities (Sublett, 2017).

STEM - STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Gerlach J. , 2012).

Summary

This study was based on the conceptual framework of Burner’s Theory of Discovery Learning, described by (McLeod, 2012). Research has suggested that there is a correlation between success and the use of STEM education as a platform for understanding. To meet the need for the increasing number of STEM professions being created daily there has been an increase in STEM education at the secondary level. This study described the benefits of using STEM education to assist students with learning across curriculums. This information was captured from the voices of educators who worked in STEM educational environments and the positive outcomes that derive from using this as a platform for learning.
Organization of Document

This study is divided into five chapters. Chapter One explains the purpose, Chapter One also provides background information for the study including research about the purpose and organization of the study research questions, theoretical foundation, and definition of terms. The second chapter details a review of literature that connects concepts and ideals and discusses relevant information. Chapter Three provides a detailed explanation of the research methodology.

Chapter Three also includes description of the populations and sample of the study, research procedures, explanation data analysis, and a description of the instruments that were used to analyze data found in the study. Chapter Four discusses the results and provides detailed results of the data of analysis and provides detailed results relating to the hypotheses, correlations between subjects, significant results and discoveries. Chapter Five expands on the conclusions, implications, and recommendations.
CHAPTER II

REVIEW OF LITERATURE

History of STEM

STEM education as a platform to enrich the K-12 learning experience is the direction that some Lead Education Agencies and districts are using to engage students, teach standards, push critical thinking and creativity. In the world community, STEM is ubiquitous and is becoming a part of what is considered 21st-century education on the universal stage.

In the United States, the science, technology, engineering, and mathematics movement began in 2005. As a result, mathematics and science were pulled to the forefront of STEM education because of the lack of curricular understanding of how to connect engineering and technology to other subjects. Many programs across the nation began to introduce STEM as a way for students to engage solely with math and science in the core content areas (Blackley S. &., 2015). Prior to 2005, there were no primary or secondary programs that taught engineering as its own subject area. This, coupled with a lack of professional development for teachers, created a silo in which STEM was instructed in some environments. However, full integration of all four contents has proven to be robust learning tools for students in core academic areas (Burrows A. L., 2018, p. 1).

Currently, researchers are seeking to create more extensive opportunities to included STEM in the fabric of all learning experiences. The idea of how to effectively integrate STEM is a unique issue for educators. Newbill (2015) conducted a study that acknowledge several indicators that show the success of integration of STEM in the classroom. Those include student performance in project-based learning opportunities, which require oral, written, research, and technological skills to progress.
The influence that STEM has on student performance at the K-12 level has an impact beyond the classroom that occurs in various facets of society. Using STEM education to develop students’ ability to think critically and creatively among countries such as the United States, United Kingdom, Korea, and China assures their technological and economic leadership in the world (Yildirim, 2016). The need to prepare students for the 21st-century global economy is intertwined with the mission to ensure student progress.

The justification for STEM education as a platform for learning is slowly gaining momentum in classrooms internationally. This new push in education also has precise and defining implications in several areas that are the focus of this literature review. The ability to mesh standards such as Common Core and Next Generation Science Standards with STEM is essential to ensuring an accessible education for all students. With this, existing literature provides a foundation for the creation of specialized schools and how these institutions use STEM to engage learners in rigorous learning.

Another essential item for consideration is the perception of STEM as seen by primary stakeholders, students, teachers and schools and how these core principals change the landscape of learning. Does STEM provide autonomy for all subsets of students to grasp learning at their own pace? Are teachers comfortable with integrating these disciplines into their content seamlessly? Addressing these issues with current research will further explain the rationale for integrating STEM into our current systems of education.

**Standardized Education and STEM**

Historically, education has been a system to prepare students to enter the workforce after they matriculate through K-12 education. As society progresses, schools are now preparing students to extend their educational experiences, through post-secondary and technical education.
The reciprocal response to these expectations has led to districts working to create rigorous multidisciplinary learning experiences that encourage critical thinking. To encourage the creation of learning environments that foster deep thinking, most states have adopted curricular standards. However, are the standards alone enough to help students make cross-curricular connections while preparing for the 21st century?

The intention behind creating standards was to advance student learning and provide a sense of rigorous understanding. Educational standards are often evidence of inducing higher student performance. Standards can provide a clear target that may increase student motivation and outcomes. Many K-12 schools across the country are now actively raising standards to improve performance. Some of this recent activity is linked to the Common Core standards which have been adopted by 45 states (Metzgar, 2015).

In contrast, there was uncertainty regarding the subjectivity of these standards and their equality across the country. Standards are subjectively chosen by individuals and groups, and the chosen standards are implicitly based on the ability of the student body. The use of singular standards ignores differences in academic abilities (Metzgar, 2015). The birth of initiatives included in No Child Left Behind prompted sweeping changes in how students’ standards were applied across the nation. One such

The No Child Left Behind Act prompted sweeping changes in how student standards were applied across the nation. One such initiative, Common Core, was created to level the playing field and provide an education that provides more depth within the standards (Secretary, 2002).

The national and international impact of a more STEM-literate education and workforce has become the focus of change over the past decade. Many global challenges need an
international approach supported by further development in science and technology to adequately address these challenges. Yet numerous educational research studies have indicated that student interest and motivation toward STEM learning has declined, especially in western countries and more prosperous Asian nations. Concern for improving STEM education in many nations continues to grow as demand for STEM skills to meet economic challenges increasingly becomes acute (Kelley, 2016).

Useful and impactful data is centered around the number of underrepresented individuals who pursue degrees and careers in science and engineering, increasing the science literacy, and expansion of a STEM capable workforce (National Research Council of the National Academies, 2013). According to Haug (2011), Career and Technology Education have been the most frequently used to encourage STEM understanding.

Documenting and escalating the STEM content taught within agricultural classes may help administrators, politicians, and the public realize their value (Stubbs, 2015). This application of STEM in K-8 education is slowly becoming more utilized the bodies that govern schools are beginning to witness its impact on student understanding. Looking toward the rapidly changing future, the 21st century skills will serve as a conduit to make the content easier to access for the diverse learners that are in each classroom. Are there unique skills that are a component of STEM that can serve as a platform to access content knowledge? Are there attributes of STEM that create better connections for diverse student populations? If so, how are teachers learning the skills to instruct students in their future classrooms? The perceptions of educators are an important portion of this research and will assist with the collection of qualitative data and understanding of this academic culture.
The literature review encompassed several topics that involved implementation of STEM and provided readers an understanding of all the interconnected areas that explain the importance of STEM implementations covered. These include Common Core standards, teacher preparation, minority performance in STEM, platforms for teaching STEM, student perception and connecting student experience to understanding. By addressing these areas, the researcher will build the framework for supporting the implementation of STEM curriculum in the general education setting.

Student understanding and school funding are closely tied to pupil mastery of academic standards, which are generated by local governments. Standards based education is the result of sweeping educational changes across the United States and other industrialized nations (Yarovaya, 2015). Buttram, (1997) acknowledged the importance of the impact of standards-based education, while also stating standard based education not being the cure for all public education’s woes (p.4).

Educational standards have continued to change and provide students with a rich educational learning opportunity based on measurable outcomes. The Common Core standards were designed to deepen the teachers’ interaction with the content and student engagement with the content (Bay-Williams, 2016). The neutrality and equality of Common Core standards provides opportunities to various subgroups to make greater connections to content from various Fields. The connection between subjects is important as educational entities seek to create a multidisciplinary experience in each classroom.

The initiation of Common Core has catalyzed a gradual increase of women and minorities with greater interest and an expansion of skills for careers in the STEM field. The more rigorous and in-depth standards of Common Core have facilitated exposure to groups
commonly excluded from the equation of learning. Common Core also allows all students to meet or engage in the learning at different points with the use of STEM as the platform. Common Core raises the expectations for student learning. The Common Core State Standards provide opportunity for girls to allow girls the opportunity to seize STEM learning opportunities while in grade school, to pursue a diverse set of college majors, and to obtain jobs that command higher salaries (American Association of University Women, 2014).

Common Core was a response for a significant slump in college readiness for students in United States, as well as noticeable disparities in science and mathematics performance of students in the United States when compared to other industrialized nations. The Programme for International Student Assessment (PISA) administered in 2006, indicated that 15-year old students in the United States average science literacy score of 489 was lower than the Organization for Economic Cooperation and Development (OECD) average of 500. This placed American 15-year-olds in the bottom third of participating OECD nations. Fifteen-year-old students in 16 of the other 29 participating OECD-member countries outperformed their U.S. peers (as did 15-year-olds in 6 of the 26 non-OECD countries that participated in terms of average scores (International Center for Educational Statistics, 2009).

Common Core, and STEM were both designed to ensure that America’s workforce possesses the cognitive skills to meet the evolving needs of the global community. Demand for post-secondary educated workers has grown substantially since 1989. During this period, individuals with a bachelor’s degree or beyond have seen 82% job growth, compared to 41% with an associate degree and negative 14 percent for those with a high school education or lower.

Projections suggested that 63% of U.S. jobs in 2018 would require an education beyond high school, 36.8 million positions would become available by 2018, 3.8 million new jobs would
be created, 33 million replacement positions would be vacated by retirees, and 70% of the vacated positions would be in occupational categories that required postsecondary education that was not required 30 years ago (Eubanks, 2014).

**Specialized STEM Schools**

As momentum increases to use STEM as a platform of learning, several unintended phenomena have resulted from this new global push. Unintended phenomena are defined as the responses to sweeping changes at the government or national efforts such as the creation of Common Core and Next Generation standards that change or alter the way instruction takes place in classrooms across the nation. A visible response to STEM education is the development of more specialized schools, specific to using the four core principals of STEM to instruct and develop the 21st century competencies of students.

The idea of a STEM school is not a novel idea, but it is one that has been revisited, reevaluated and over the decades. Encouraging the use of STEM, to support other content areas, requires the creation of more specialized programs or curricula that has STEM as the focus. STEM schools existed in the earlier part of the 20th century in New York, with their single gender focus, developing student talent in science, mathematics, and technology with specific characteristics of learning developing as a result of location (Erdgoan & Stuessy, 2015)

These earlier derivations of STEM schools were to raise skilled workers for specific industrial areas (p. 79). The evolution of STEM schools led to the development of the core characteristics of these schools, which require educators to use their ability as facilitators to develop instructional practices that are focused around meaningful and appropriate learning goals.
The framework of these schools uses the principles of science, technology, engineering and mathematics to introduce skills and allow students the cognitive practice to manipulate these skills outside of school. These transferable skills are also considered the most desired in the community that these schools serve. Technologically-literate citizens are needed to ensure that each respective nation can meet the demands of the increasingly competitive economy through the application of the innovative techniques required by science, technology, engineering and mathematics.

As scientific and technological developments accelerate the world every day, the need for a skilled work force that will take part in this endeavor will increase. Skills needed for 21st century citizens to survive in the modern world include communication, critical thinking, creativity and collaboration (Partnership for 21st Century Learning, 2015). The need for these skills made it imperative for students to experience such learning environments.

Because of this need for more STEM environments, recent initiatives have been implemented to make STEM a part of the daily academic environment. STEM education is an interdisciplinary area of study that bridges the four disciplines of science, technology, engineering, and mathematics. STEM derives its philosophy from four important basic disciplines (Meng, 2014). Knowledge that is obtained since the emergence of STEM was revealed as a result of these disciplines. These disciplines were developed by being filtered through education. According to STEM, the main goal of education is to prepare a person for life and ensure that one lives competently (Yildirm, 2016). A competent life is only possible with living an educated life.

The framework of STEM schools is to provide research opportunities to engage students in the content. These schools often broker opportunities in the community for this research to
occur. Instructional practices of educators in these buildings seek to make their students experts in the STEM areas. Educators have the ability produce these meaningful opportunities with engaging and appropriate learning goals (Bransford, 2000).

The role of teachers and students as it relates to international effort to increase the use of STEM is still being defined. Ideally, STEM will grow to be deeply entwined into the fabric of education, which signals a change from the current teacher pupil interactions. Understanding the needs of educators to facilitate in a manner that allows students to grow cognitively and use these transferrable skills is the next step in this journey with STEM education.

**Teacher Preparation**

Education preparation programs have changed significantly since the birth of the common schools in the early nineteenth century (Nguyen, 2018). These early programs were designed to train teachers with common modules that were shared among universities. This preservice educator model of preparing educators via essential courses relating to nature of learning, cognitive development, pedagogical methodologies, and field experience is the model that is still followed in programs across the nation (p. 77).

Although the tenants of teacher preparation programs have been able to provide a solid foundation in the past, the present influences of politics, economics and social phenomena have spawned many institutions to revisit how they are preparing tomorrows educators. Katitia’s 2015 study highlighted that preparing 21st century educators should involve training teachers in content areas but also that nature of knowledge and inquiry in different fields is needed to ensure the whole child is engaged. The core literacies of the 21st century involve the inquiry that is seen with science, engineering and mathematics, with the bridge to understanding being the access provided by technology.
In 2014, Corlu presented a study that suggested most teachers lack the integrated teaching skills required to provide an effective STEM education when they begin their professions. Some researchers argued that regional problems seen in STEM fields sometimes result from problems with access to undergraduate STEM programs and with the quality of STEM teachers, and that is why universities can be part of the solution regarding the problems encountered in STEM education (Hagedorn, 2012).

The number of preservice teachers entering STEM fields has declined drastically across the globe and in the United States. Although many pre-service teachers have a strong interest in STEM education, their ideas of how it can be implemented vary. These teachers agreed that STEM education is to prepare students for real-life conditions, to develop psychomotor and mental skills, establish interdisciplinary integration skills and provide improvement of 21st century skills (Erdogan I. a., 2017). Even with this knowledge there are concerns that teachers possessing knowledge only in their fields of specialization will not be enough to create the human resources required in the United States (Cinar, 2016).

The need for teachers to have the skills present to instruct students is one of the greatest struggles being experienced in the STEM field. An examination of relevant literature determined the views of teachers and pre-service teachers on STEM education (Eroglu & Bektas, 2016; Kızılay, 2016) were not enough. Eroglu and Bektas (2016) worked with five science teachers to reveal the opinions of science teachers on STEM and STEM-based practices (Erdogan, 2017). Eroglu’s (2016) research on pre-service science teachers noted teachers perceived thoughts on the limitations of STEM education and stated that STEM education practices could only be associated with topics in physics. These practices could not be associated with topics in biology and chemistry courses. Teachers also detailed that STEM education practices are costly
and time consuming (Erdogan, 2017). The opinions of pre-service teachers are crucial to understanding how and why STEM education is implemented at a conservative rate indicated in many districts. The academic preparation of teachers has implications for the curriculum of STEM education. The infrastructure and pedagogy of conventional STEM education has been under review, as too many students lose interest in STEM subjects at an early age, with fewer students pursuing advanced degrees (Owens, 2012).

The experiences that students have with science, technology, engineering and mathematics are influenced by their instructors’ access to quality professional development in these areas. This is also applicable for teachers when it comes to creating a cross-curricular instructional experience with STEM. Truly understanding what teachers are able to ascertain and apply was observed in the Teaching and Learning Survey of 2013, in which the participation of STEM teachers and non-STEM instructors revealed that there is no significant difference in teachers of Non-STEM instruction were engaged in STEM professional development (Chiyaka, 2017).

Student Perception of STEM

As previously discussed, the desire for industrialized nations to remain at the forefront of economic growth and technological knowledge is dependent upon talent acquisition and development in STEM fields. In 2013 The National Science Foundation recorded attrition of students in STEM programs as a result of a disproportionate reduction of interest in post-secondary STEM programs by many students. Although one-third of students expressed interest in STEM majors before starting college, the actual STEM enrollment rate was not that high (Chen, 2013). The need for students to fulfill roles that require critical thinking and creativity hinges greatly on their introduction to STEM at earlier ages.
There are three major influences of students’ perceptions of STEM that have been observed. These influences are also responsible for the current hesitation of students to fully engage with STEM beyond certain academic milestones. Student attitudes and perceptions toward STEM are affected by their motivation, experience and self-efficacy (Roberts, 2018). Brown et. Al. (2016) studied the relationships between STEM curriculum and students’ attitudes and found student interest played a more important role in intention to persist in STEM when compared with self-efficacy, which is defined as the student’s perception of their abilities.

Student experience is also identified as an important variable in student engagement in STEM. This is because the formal environment is often one that isolates students from the opportunity to collaborate, informal experiences are abundant with opportunities to share knowledge (Roberts, 2018). Students typically will preserver and are willing to take academic chances when there is a community of support. More informal learning experiences are being encouraged as an outlet for students. These experiences should provide meaningful exposure to problem-based learning that carries significance in the students’ current academic journey. Student motivation is also a response to having authentic investment in the learning and how it will occur for students. Informal learning promotes access and opportunities to participate in STEM that encourages students to experience learning outside of the boundaries of learning expectations.

Along with earlier introduction to the idea of STEM, there was also notable research in making STEM knowledge a long-lasting and impactful experience. The organization of this environment is essential to the development of students’ thinking. The learning environments should be organized around driving questions that motivate students to apply the science that they learn (Krajclik, 2017). Krajclik believed that classroom resources should center around...
experiencing phenomena, conducting investigations, using technology tools, and reading materials that extend students’ first-hand experiences of phenomena and support science literacy.

Students perceive information according to its immediate application and relevance to their world. Several countries have taken legislative action to reroute funds to ensure that students have a foundational understanding of STEM. In Turkey, the process for conceptualizing STEM has become applicable to students using after school programs and educational initiatives to build students’ interest through experience. Turkey, as a nation, is steadfast in the belief that identifying the goals and the content are noted as two critical steps in the design of STEM education programs.

Building the programs on students’ early interests and experiences and engaging them in the practices of STEM education are noted as crucial factors in developing and sustaining their motivation and engagement with STEM education (Baran, 2016). STEM education is a collective response, first in preparation, as well as identification of the meaningful relationships to other school content and applicable world interactions. These interactions must also take into consideration how the socioeconomic, gender and cultural aspects. How does the socioeconomic status of a student influence their interest in STEM? Is there any discernible connection between cultural expectations based on gender and race that develop self-efficacy in STEM education?

**Minorities and Women in STEM Education**

The global impact that STEM is expected to have touches every student in every class, across the globe. Its purpose is to provide each learner with the structure needed to develop critical thinking skills and creativity, that is the foundation to the 21st century. However, what is the status of minorities and women and how well do they persist in the STEM fields? Does STEM allow for diverse learners to access the content at different points? STEM fields need
women and minorities to ensure economic growth, develop talent for the future, and diversify the STEM education fields.

STEM has seen historically low graduation rates; an unintended consequence is the reduction in the number of minorities and women participating in these programs. Education beyond high school is necessary to achieve desired levels of competency and efficiency in STEM fields. Despite the demonstrated need, there is a shortage of individuals trained in these areas, especially women and ethnic minorities (The Business Higher Education Forum, 2006). This diversity in STEM is a relevant and timely concern when developing the framework for this educational focus.

The persistence of any student in STEM is based on their experiences, motivation and self-efficacy. However, for students in minority groups there is a need for additional support to persist in STEM education due to the vast similarities in each population engaged in STEM education.

Qualitative data from King’s (2016) study indicated that women’s performance in STEM at a post-secondary level, were not dissimilar from that of their male counterparts. What can be hypothesized is that the multiple routes of understanding that STEM provides for students is successful in transferring new skills and knowledge.

Lack of diversity in STEM education beyond secondary education is a response to the number of educators who are actively engaged in the field. The presentation of content for STEM classes as unique to each subject, in sequence or concurrently, is being challenged. Integrative approaches have been suggested at the post-secondary level to combine instruction in two or more of the STEM subject areas and/or between/among a STEM subject and one or more
other academic subjects (Sanders, 2009). Minority and women representation in STEM further impact the K-12 connection of STEM.

Early interventions to recruit and guide underrepresented students into the STEM pipeline is critically important. Federal programs, such as Gear Up and Upward Bound Math and Science, prepare low-income and first-generation high school students to pursue degrees and careers in math and science (Mau-Chang, 2016). This is also evident among K-12 teachers who are working to introduce those early interventions and interactions with project-based learning, as well as a strong teacher preparation in the field.

Students with disabilities also represent many minorities that are underrepresented in the field of STEM. Students with disabilities were less likely to enter STEM fields because of the lack of community connections with the content facilitators and cohorts. The challenge students with disabilities face when pursuing STEM degrees is the lack of effective accommodations for improving STEM learning outcomes for students with disabilities (Moon, 2011).

Moon also reported that STEM faculty participants were diligent with their students and provided positive feedback on group-based learning, which can help these students learn how to collaborate with their classmates as well as understand the class materials effectively. Other academic accommodations included online-based learning materials (e.g., animations, interactive tutorials, and video clips), open-book, and pre-lecture quizzes.

**College and Career Readiness**

The goal of the education system in United States’ is clear: Every student will graduate high school either college or career ready. Curricular decisions for students are based on standards from various states (U.S. Department of Education, 2009). However, there is a
disconnect in what American students know as well as their knowledge base and its relevance in this century.

While the purpose of Common Core was to bring coherence to the academic functions of school systems—curriculum, assessment, and instruction—to create and promote a common high standard for teaching and learning, the National Assessment of Educational Progress (NAEP) is intended only to provide a way to measure and compare student performance across states and districts (Council of Great City Schools, 2014). The importance of NAEP was to revel the direction of American education when preparing American students for a future in the various technological, science and engineering industries.

Previous NAEP and Trends in International Mathematics and Science Study (TIMSS) comparisons indicated that students in the United States were struggling in the areas of mathematics and science (Lim, 2017). Although Common Core allows for more exposure to more rigorous, in-depth connection of the, material there is still a lack of a surmountable and integration of the STEM culture in many of K-12 institutions in America. The platform of Common Core is a foundation for the integration of STEM culture into the classroom. This also will encourage more intentional planning of each core principal into the development of each content area.

Career and Technical Education in Science Technology Engineering and Mathematics

The domestic marketplace and international marketplace are evolving to include innovative technologies that improve productivity and require new skills sets and knowledge base for the workforce (Asunda, 2012). Today’s knowledge-based society that thrives on technological transformation has little room for those who cannot read, write, and compute proficiently, find and use resources; frame and solve problems, and continually learn recent
technologies and skills, as well as work in technical occupations. Thus, there is a focus on providing student development in the areas of science, technology, engineering and mathematics (National Research Council, 1996).

Career and Technical Education (CTE) has long been the vehicle to prepare the future workforce. CTE programs address parts of science, mathematics and technology, address STEM-related careers in auto technology, medical technicians, registered nurses, process control processors, machinists, financial managers, and many other kinds of technical-related careers (Stone, 2011). In 2009, the International Technology Education Association (ITEEA) proclaimed that the delivery of STEM education content was closely aligned with the same core content as the Standards for Technological Literacy (STL).

ITEEA stated that the content contained within the STL standards was the foundation for students to develop 21st Century STEM literacy—the very core of abilities needed for students to become advanced problem solvers, innovators, technologists, engineers, and knowledgeable citizens. ITEEA believed that all true STEM programs must include STL as a ladder to help students achieve STEM literacy (International Technology Education Association, 2009). This connection between the two worlds allows teachers to create meaningful and goal oriented curricular opportunities. As the industry focus shifts to increase the innovative technologies and experiences for students, it is important that there is a body of literacy and standards to support this learning.

**Post-Secondary STEM**

As students matriculate into college or career, the skills of their K-12 education will be a consistent and determining factor of their success. Post-secondary institutions are embracing the STEM curriculum and becoming more expansive in the lower levels of education to ensure that
there are increasing numbers of STEM majors in these post-secondary institutions. The number of students who enter STEM programs have decreased in these areas. Student persistence in STEM fields deserves close attention given the alarming attrition rates from such programs—particularly for women—considering the increasingly problematic nature of staffing difficulties and turnover among science educators and practitioners in North America (Simon, 2015).

Over the past 20 years, the number of college-bound students interested in STEM majors dropped by 50% and approximately half of the students who enter STEM programs transfer out before completing their degree (Chen, 2013). The physical sciences and engineering are at risk, as evidenced by substantial declines in the number of earned bachelor’s degrees and doctorates in these fields over the past decade (National Science Foundation, 2013).

Self-efficacy, self-achievement goals, and academic emotions are all a part of the driving motivation for students to pursue these post-secondary STEM fields. Bridging the gap between grades K-12 is essential to preparing students. The National Science Foundation has several initiatives that address these three characteristics. For the local community, there is a grassroots effort to reform the current system of education to prepare students for evolving career and college expectations.

Progress in education necessitates periodic school reform initiatives, particularly if economic markets demand changes. STEM academies demonstrate the changes taking place across the country, and certainly in Texas. Completion of the first 21st century decade has launched a global competitiveness pace in financial markets that has initiated an instructional paradigm shift for teaching and learning (Gonzales, Jones, & Ruiz, 2014). Shifting these patterns of thinking will create the bridge of concepts, knowledge, and literacies of STEM education.
Previous Studies

The narrative of STEM in the educational system is a 15-year history of preparing the nation to function in the global political and economic system. Research in the western STEM agenda has primarily been one of vocational and economic goals (Williams, 2011), funded by governments and promoted by politicians. Various economic imperatives were used to justify its importance and shifts in workforce patterns or instances of economic downturns tended to result in an increased focus on STEM (Williams, 2011).

In western nations, the STEM research focus has emphasized how politics has begun to shape the curricular framework of science education, fidelity of science instruction in the classroom, teacher confidence, expansion and integration of STEM in every classroom (Blackley S. a., 2015). With the need to increase student performance in education, legislative and federal mandates to create these opportunities were a large part of the early research of STEM curricular instruction. As previously mentioned, the emergence of STEM was at the behest of a political agenda grounded in vocational and economic imperatives. The push from governments for increased numbers of students opting for STEM subjects in senior secondary and tertiary STEM-related courses has been a challenge for educators (Office of the Chief Scientist, 2013).

Teacher fidelity and subject content knowledge was/is a key research focal point of STEM implementation. Research in the United Kingdom indicated there was a disconnect by most educators on how to instruct for engineering at the K-12 level (Bybee, 2010). In the areas of Mathematics, English Language Arts and Social Studies, case studies were accessed and showed that teachers typically struggled to instruct cross curricular due to the lack of literacy in the STEM fields. Differing interpretations of the meaning of ‘technology’ led to confusion and frustration (Williams, 2011). Traditional primary school teachers lack proficiency and
confidence in teaching both science and mathematics, and instead favor the teaching of literacy (Ross, 2011). As there is a paucity of mathematics and science-trained secondary school teachers (Office of the Chief Scientist, 2013), many of those teachers timetabled onto lower secondary classes are teaching ‘out-of-field’ (e.g. they may be trained as Health & Physical Education specialists, yet are required to teach Year 8 mathematics). The previous research has prompted later developments that have propelled STEM into classrooms across the western nations, which has also generated new questions regarding the fidelity as to how these programs are being executed.

**Unresolved Research**

As STEM becomes synonymous with daily educational, curriculum, and student development goals for 21st century students, there will continue to be new questions to answer. From previous studies, the areas of integrating, emphasizing and making STEM a mandated norm are still being scrutinized for developing the ideal framework of instruction. The basis of this research is built from this lack of information on how this impacts students.

. This study will further the research needed to make economic decisions for investing and growing the STEM curriculum in K-12 education. To summarize, the research that is present today is only a basis of what can prove to be an educational revolution that will allow all students an access point to learning for success.

**Summary**

This review or professional literature examined the influence of STEM on student learning, thus furthering the need for STEM development as a foundation for curriculum delivery. Existing research is limited in its scope. Because of the novelty of STEM, there is a need for an active accumulation of knowledge concerning academic impact. Disciplinary core
ideas are powerful in that they are central to the disciplines of science, serve as thinking tools to make sense of phenomena, and serve as building blocks for learning within a discipline and in making connections to other ideas (Stevens, Sutherland & Krajcik, 2009).

Thus, the need to understand STEM goes beyond defining the four core principles of this foundational learning. There is a plethora of information that provides a foundational interpretation of where academics have focused largely on understanding the purpose of each area. Minimal studies exist regarding how STEM has improved student understanding in subjects that have used STEM to integrate subjects.

The challenge of developing STEM-literate citizens and building the STEM professional pipeline is multifaceted and represents more than a lack of academic preparation or achievement. Evidence regarding student interest in science—which predicts students’ pursuit of science-related careers—is a critical part of the puzzle, as too many high school students report that they dismiss STEM career possibilities because they neither know people who work in STEM areas nor understand what such people do (Lemelson Center, 2010).

STEM has implications far beyond the classroom; its social, economic and global influence are evident. The hands-on learning that occurs has proven to create “thinkers,” one of the world’s most proven assets. Research on youth development may offer important and applicable lessons about how to most effectively engage students. The youth development literature has revealed, for example, that hands-on project learning (often called inquiry learning) and peer-to-peer interactions have positive impacts on metacognitive development, academic outcomes, and student motivation (Gamse, 2015)
CHAPTER III

METHODOLOGY

This study was designed to determine if there is a correlation between student academic success and the use of STEM as a platform for learning. The researcher utilized case studies and interviews to gather data on teacher perspective and specific measures that show transferrable skills from STEM to the core content areas. Case studies were used because they allow for exploration of the phenomena of STEM education (Center for innovation in research and teaching, 2018). Interviews were implored because of the options of structure that are available. Unstructured interviews allow interviewees more freedom in their response, while allowing interviewers autonomy to redirect responses to ensure topics are adhered to. There is also the option of semi-structured interviews in which the interviewer develops preset open-ended questions that must be answered (Jamshed, 2014).

Case studies use multiple methods’ such as interviews, observations, documents, and archives to gather data (Ary, 2014). The research design helped to elicit evidence that supported the theory that STEM has some measurable impacts on students cognitive and academic progression. Using the case study method, the research observed how educators incorporate STEM into their academic planning and how that subsequently influences the educators’ next steps in instruction, attitudes, and instructional behaviors of teachers and students when introducing concepts or ideas using STEM (Erdogan, 2017).

Teachers who participated reported their experience instructing in STEM environments and non-STEM learning environments. They were asked to examine whether there were
any signs that students a) used skills acquired in STEM to help manage other core areas b) illustrated that students’ cognitive growth is expanded by intentional design around STEM and c) students develop a greater interest in science, technology, engineering and mathematics.

There were several specialized STEM schools in the state of Tennessee. This included one elementary and secondary school in East Tennessee, three in Middle Tennessee regions and one in West Tennessee. Since these schools were a hybrid of specialized schools that also instruct core content areas, this made the population desirable for conducting research. A caveat was that the teachers interviewed also needed experience teaching in schools that were built with the traditional curricular concepts for them to make considerable comparisons to how student knowledge develops.

The researcher interviewed educators who currently engaged with viable STEM programs. Each participant was at a different state of STEM integration. The focus groups provided diversity in perspective and were compared to the one-on-one interviews. The interviews created a rich description of how STEM influences pedagogy and how STEM enhances lesson plan development and modeling for students to create a clear epistemology of student learning trajectory.

Individual interviews introduced information that aligned to the ideals of the individual as well as the ability to provide deeper insights to STEM education and how its structure causes changes in student interaction with content. However, the focus group was completed to provide general perspectives, and individual interviews discouraged group dynamics or bias that could have possible during the study (Malone, 2011).

The case study introduced research that focused on STEM curriculum, provided a description and understanding of how STEM can increase student understanding across
multiple subject areas that have a traditional curriculum (Ary, 2014). Data collection during the research established patterns during observations of student learning to apply. The study proved the ways that STEM appeared to increase student cognition in core subject areas by allowing teachers to provide their comparative data of student performance. The study prompted understanding of the structure of a STEM educational environment and could possible allow others to understand how the STEM initiative is currently utilized.

**Research Question(s)**

What are the designated differences educators, who have experience in traditional education settings, see when STEM is incorporated as the basis for learning?

- How do students think differently?
- What is the progression in thinking when compared to traditional schools?

**Population**

The population was comprised of instructors at a STEM high school, STEM middle school and STEM educators who were working in traditional school at the time of the study. Interviews were conducted with teachers who taught STEM-related and non-STEM related subjects. STEM educators were defined as those individuals who instruct science, technology, engineering and math using the processes of inquiry or investigation. Non-STEM educators were those individuals that instruct subjects that indirectly introduce aspects of science, technology, engineering and mathematics.

Administrative members of the school community were also be interviewed as a part of the study, as they had knowledge of the global response of STEM in the building. Triangulation of data occurred through an analysis of educator lesson plans and case study of STEM school culture.
The teacher participants chosen for this study included six in service STEM teachers and two non-STEM educators. The teacher interview is found in Appendix A. This type of sampling allowed the researcher to adjust during teacher interviews and obtain the perspectives of pre-service and professional educators.

**Grounded Theory**

Research for this study is predicated upon grounded theory research, which allows for the research to develop theories as data are collected (Tavallaei, 2011). The research approach and methodology, employing a combination of inductive and deductive methods, falling within the interpretive paradigm, relies on qualitative methods of data collection and a unique system of coding in data analysis (Dimmocks, 2012). The interviews and case study of STEM schools, educators, and pre-service educators allowed the researcher to develop a theory relating to the ways STEM can influence student performance in core academic subjects. Using the interviews that were conducted, the researcher developed a theory of the perceived understanding of STEM education by educators.

**Data Collection and Instruments**

Data were collected through interviews and a case study that focused on the use of STEM in cross-curricular subjects and how this integration influenced student performance. Teacher interviews, educator surveys, case studies, and curricular lesson plans were the instruments used for the qualitative component of this mixed-methods study.

The survey was developed using customary interviewing protocol and parameters. All interviews were semi-structured and focused on STEM instruction across content areas. This allowed the interview to provide deeper context relating to the ways that STEM influences the school’s environment (Gill, 2008).
The researcher used open-ended questions to maximize the information that could be attained and to describe the unique aspects of STEM education. A digital version of interviews was utilized because it was more beneficial and encouraged more participation due to distance constraints and time constraints. The interviewer created a set of interview questions that were disseminated digitally and maximized efficiency, encouraged participation, and secured the data electronically. Focus group interviews were used to compare group ideas to individual ideas. Interviews are significant because they provide context to the research and more information related to the phenomena.

The pre-service educator interview was the first set of qualitative data collected during this study. These interviews were completed by pre-service educators pursuing STEM certification who were investigating how to integrate the STEM framework into a classroom. Their perception of how STEM education is important to understand the overall influence that STEM has on teacher’s ability to help students understand cross-cutting ideas in various subject areas.

Data collected from veteran educators provided better understanding of how this instructional change influences the conceptual understandings for students, in all subject areas. Veteran teachers can also identify any noticeable patterns of students’ understanding in STEM education.

Research Procedures and Time Period of the Study

The first step in the timeline of the study was to obtain approval from the University’s Institutional Review Board since the methodology contains human subjects, prior to the study. Once approval was received, the researcher contacted and obtained approval from three school districts with a STEM/STEAM focus. Once approval was obtained, the study moved forward.
This study was conducted during the spring term. The purpose of completing this study during this time was to focus primarily on the teachers and their interaction with STEM as a content. Schools were identified by the researcher for the target audience. Schools were then categorized as follows: fully STEM immersed, STEM-based programming available, and non-STEM schools. Next, data were collected on curricular design processes, STEM curriculum, and student performance in core content classes. Subsequently, the data were categorized for each school based on noted patterns.

Teachers were asked to participate individually and then as part of a focus group. All participants were required to complete an informed consent form to participate in this study. The informed consent provided the researcher the permission required to perform this study and later publish the findings of this study. Teacher selection was based on each teacher’s experience in the field of STEM, and interviews were aligned to the hypotheses of the research. This research concludes with a case study on a STEM program from one of the research schools. Once all data were acquired, the researcher completed the triangulation component of the study.

Summary

The introduction of this chapter provided the purpose of the methods used in this study, followed by the population of participants. The purpose and importance of this study are also noted, and an explanation of how the grounded theory was aligned to the research is provided. Data collection techniques and analysis were subsequently detailed. This information was provided to offer a detailed explanation of how the research was conducted and how the information was analyzed to draw conclusions. Additionally, the research timeline for this study was noted.
The following process was used to analyze the qualitative data for this study.

1. Individual teacher interviews were completed with 7 teachers, via teleconference, face to face or Zoom conference.

2. Focus group interview was conducted via teleconference, and the researcher used a 3rd-party recording system to produce a digital transcript.

3. The researcher reviewed this recording to compare with the digital notes that were transcribed.

4. The researcher utilized individual and focus group interviews to acquire data regarding STEM as the foundation of learning concepts.

5. The researcher sought to determine if there were connections between the interview data and the case study.

6. The researcher conducted a review to identify the themes of the final portion of qualitative data.
Chapter IV

Findings

The purpose of this study was to determine the influence of STEM education, as a foundation of learning, and determine how teachers commonly see skills from STEM manifest into their daily classroom. This qualitative inquiry sought out seven educators from across the state of Tennessee that taught in public, public charters, magnet, and STEM-focused schools. These teachers were from districts in west, east, and middle Tennessee. These educators all had unique perspectives as they either were currently educators or served in a STEM curricular role. It was essential that the researcher is aware of any relevant aspects of self, including any possible biases and assumptions, any expectations and experiences to qualify his or her ability to conduct research (Greenback, 2003). This qualitative study provided a rich and detailed explanation of STEM education in the classroom, from educators that are responsible for actively facilitating the education of students.

Data collected were very detailed-oriented and there were multiple points where there was overlap in the information that the researcher collected. This chapter presented the findings that the researcher uncovered from data collected and analyzed using the conceptual framework that was constructed for this study.

The objective of the analysis was to determine the educator’s response to the research question:

How does STEM influence student’s performance in core content areas?

Responses were analyzed from the interviews using a list of semi-structured questions. (Appendix A). The educators explained their observations of students’ abilities in the areas of critical thinking, responsiveness to academic challenges and overall use of transferrable skills
learned in STEM. Additionally, the researcher completed a focus group interview with three of the teachers that participated in the research to determine what the collective felt where identifiable changes in academic performance of students’ that can be related to STEM as a foundation of learning.

Using the Nvivo 12 coding software data were analyzed and presented in exploring diagrams and hierarchy of interview responses to the queries regarding STEM education. An Explore diagram was used to identify the areas in which experts saw STEM actively changing the academic performance or interactions with the knowledge that students are having. The data detailed in this research were from a diverse group of educators with educational experience in various areas of curriculum and instruction.

Coding was created using a frequent word or similar phrases from all the interviews. The researcher created priority codes based upon the literature review, but other emergent codes developed from the results of the interviews and once the transcripts were completed. The emergent codes were created based on a common phrase and word report. Coding was a process used to distinguish a clear view and prevent any biased from the researcher.

Four priority codes were used during the research: student thinking, transferrable skills, academic skills, and developing skills. These were codes based on the literature review and were anticipated to be common threads that were shared from one educator to the next. The new code that appeared was student engagement in course work. This was introduced with STEM as the foundation of learning. A complete list of all codes that were created, along with the phrases that were associated with that code is included in Table 4.1.
Table 4.1

*Major Codes of the Situation*

<table>
<thead>
<tr>
<th>Major Categories</th>
<th>Associated Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Thinking -p</td>
<td>challenge, ability, different, critical, thinking.</td>
</tr>
<tr>
<td>Transferrable Skills -p</td>
<td>ideas, transferred, approach, process</td>
</tr>
<tr>
<td>Academic Skills-p</td>
<td>question, persist, understand, research</td>
</tr>
<tr>
<td>Developing Skills -p</td>
<td>direction, questioning, discussing, scaffolding</td>
</tr>
</tbody>
</table>

There were several tactics for sorting these seven individuals: one group was for STEM teachers the other STEM-related fields/coaches; one for beginning teachers in year two through ten, while the other more experiences group was in year eleven through twenty. Participants taught in large urban areas in West, Middle and East Tennessee, in public and public charter schools. Educators worked in secondary and elementary schools, and one educator served as coaches.

**Teacher Statistics and Grouping**

![Teacher Experience Chart](Figure 4.1 Sampling Purpose)
Selection of Participants

Seven districts/charter schools were contacted via email for permission to perform research within their county. Of the seven, three districts and one charter agreed to participate in the study. Once permission was granted, the researcher contacted schools within those districts that had STEM programs that were active parts of a student’s curriculum. Twelve schools were contacted, of which three schools and seven teachers agreed to participate in the interview. Each teacher was provided consent forms and was assured that all information would be kept confidential. Interviews were completed face to face, by phone, or through Zoom conference, lasting on average 30 minutes.

Participant Demographics

Participants were employed as educators in secondary and elementary school settings in three municipal school systems in Tennessee. The teaching experiences ranged from one year to 15 years of experience. The subject areas that teachers worked in were: STEM, Science, Math and STEM coaching. Each of the participants held a bachelor’s degree. Additionally, five had master’s degrees. There were three male educators and four female educators that participated.

Most interviews took place via phone or Zoom conference with after the school day had ended. Those interviews contacted face-to-face were completed in the teacher’s classroom or office. The educators that were selected each have a background in STEM outside of the classroom with four of the teachers entering the career of teaching from other STEM career fields. There were either direct or indirect interactions with STEM as a foundation of learning for students. To report all speakers will be referred to by a four digit alphanumeric code to preserve anonymity.
Interviews

**Academic skill development.**

This strand reviewed which areas of academics that teachers tended to see students struggle. The question was “*What academic areas do most students tend to struggle with?*” To understand later in the research how STEM is improving or assisting students with improvement in noted areas. This was a prominent and direct question as the educators are privy to patterns in student performance and their ability to make connections from one idea to the next based on their current foundational skills. Understanding the ways in which students form pathways to develop their thinking is critical to provide instruction that has been fine-tuned to in ways that address the needs of individual students’ (Fuchs, 2016).

Participant REF1 noted that the academic skills that students seemed to struggle with were ingenuity, brainstorming and researching to support ideas and find new information. “Students have to be taught how to brainstorm or even come up with ideas, which makes it difficult for students to embrace the idea of research fully.” The participant also went on to explain how limited student creativity, especially in multi-process opportunities, is an important part of being able to progress in areas of science and mathematics. “Most students have not had the experience of having multiple solutions to the problem. At the start, students are always looking for the answer to the problem.”

The ability to research was a skill that was mentioned by REF2 when asked to collect data or share what they find while researching ideas. “Research skills are the common academic skill that students struggle with because all they want to do is look up information and copy and paste and there is difficulty or resistance to gathering authentic data.” This is similar to REF7
who stated that with the students served this year “There is difficulty when gathering and organizing data for students.”

Research skills was an idea that was echoed in a later interview with REF4 who also discussed how with this limited ability in creativity and brainstorming could be attributed to difficulties in reading and mathematics. “There is difficulty with literacy both from a quantitative standpoint, as there is a steady increase in student performance in literacy on a state test. Literacy skills were also seen when there is a need to access a task through text in order to accomplish another chance or do something else. Historically mathematics has been an area of success, but there has been a slight reverse in this area.”

REF5 identified reading comprehension as one academic skill that was difficult for students to use in accomplishing a task. “The students struggle with reading comprehension in terms of realizing that this not just a string of words that create a sentence but there is meaning.” Another academic skill that the teacher indicated that students struggle in was analyzing data. “This is similar to just having comprehension skills, science data is not just a number floating around but that there is meaning to these numbers.”

The researcher predicted that there would be multiple overlapping ideas among the educators and probed further to understand better how these influenced students in other areas as well. Understanding how STEM furthered student development was further discussed in the next portion of the interview. A sub-question was asked to determine how educators saw these deficits manifest themselves “Can you provide examples of how these deficits manifest themselves?” REF7 noted that the most common example of these academic skill deficits was “Through assignments that require students to organize and summarize data that is given to them.”
REF2 typically observed this deficit at the beginning of assignments when students struggled to use the information even to get started with assignments. “Going back to their ability to research many students sit in class and look at work and say I do not know how to do it. They are not able to start because they lack or have not been exposed to those research skills that are needed to move forward.”

Table 4.2

Data sorted in levels of coding Q1

| Research question one: What academic areas do students tend to struggle in? |
|---|---|---|---|
| **Raw Data** | **Open Coding** | **Axial Coding** | **Selective Coding** |
| “Students are having to be taught how to brainstorm or even come up with ideas, which makes it difficult for students to fully embrace the idea of research.” | Taking information and analyzing it for use. Students are not readily able to produce multiple answers. Organizing information into categories is skill that needs further development. | Students lack or haven’t developed critical thinking skills in the areas of analysis and processing steps. | Teachers have identified the areas of literacy comprehension and analysis skills as areas that students consistently struggle with. This is based on students’ ability to perform on state test and formative task in the classroom. |
| “Most students have not had the experience of having multiple solutions to the problem. At the start, students are always looking for the answer to the problem.” | | | |
| “Research skills are the common academic skill that students struggle with, because all they want to do is look up information and copy and paste and there is difficulty or resistance to gathering authentic data.” | | | |
| “There is difficulty when gathering and organizing data for students.” | | | |
| “There is difficulty with literacy both from a quantitative standpoint, as there is a steady increase in student performance in literacy on state test. This is also seen when there is need to access a task through text in order to accomplish another chance or do something else. Historically mathematics has been an area of success but there has been a slight reverse in this area.” | | | |
| “The students struggle with reading comprehension in terms of realizing that this not just a string of words that create a sentence but there is actually meaning.” | | | |
| “This is similar to just having comprehension skills, science data is not just a number floating around but that there is meaning to those numbers.” | | | |
| “Taking information and analyzing it for use. Students are not readily able to produce multiple answers. Organizing information into categories is skill that needs further development. | | | |
| Students have historical data that shows their struggles in math and literacy. Struggling to read and make sense of text, to use it for future application. Difficulty understanding how to comprehend subject specific literature. | | | |
| Students lack or haven’t developed critical thinking skills in the areas of analysis and processing steps. | | | |
| Teachers have identified the areas of literacy comprehension and analysis skills as areas that students consistently struggle with. This is based on students’ ability to perform on state test and formative task in the classroom. | | | |
STEM Impact on Skill Development

Teachers shared how the use of STEM has affected student performance in each of the respective subjects that each one instructs. The researcher used the second node, skill development, to understand how teachers viewed STEM as an opportunity to develop academic skills that were identified as the areas in which students struggled with the most. The question used to determine the skill development was: “Have you used STEM as a platform to help develop these skills?” Teachers consistently provided the same description of observations or used STEM to assist student abilities to develop those needed skills. From this, there were multiple examples of how STEM has provided an opportunity to refine those academic skills previously need additional academic support.

There was one sub-node that appeared at this point, and that was engagement. REF4 stated, “I think the number one benefit that we have seen with our STEM approach has been engagement and perseverance.” This was further defined as skill development through the ways each skill is applied holistically and not individually introduced to students “So our main thing is showing the application to a real-world context. We also try to integrate them as much as possible within other subject areas to make sure the students see that we do not do that in isolation.” This was an idea that was repeated from REF5 who lamented a similar introduction and practice with these deficient skills in the STEM classroom “I know in my classroom I just try to expose them to the skills because practice makes permanent.” This reference also specifically spoke of how the engineering design process played a substantive role in developing skills “So. In my class, the way skills are kind of developed is through talking and using the engineering design process and one of the most important parts of it are the same redesign and rebuild.”
REF1 also stated that to intercede and help develop these skills, there was repeated use of the engineering design process. This helped increase students’ literacy and analyzing skills that were previously mentioned when referring to skills that students struggle with academically.

“Students engage in projects for up to 6 weeks which make them continually engage in the process of reading and analyzing to get to the solution.”

When considering the importance of having these universal skills, as identified by the participants, then it was essential to examine the influence of engagement in the overall use of STEM in the classroom as an underlying factor of student development. After interviewing several of the participants, this became a new sub node that presented itself. The engagement of students is crucial to overall understanding of an academic concept.

Engagement was not the node that was presented at the beginning of the literature review, as there was more evidence that supported looking through STEM through the scope of critical thinking, academic skill development and the use of foundational skills. The researcher found, from participants, that there were more opportunities with STEM for students to take an active role in learning. Research on engagement in mathematics highlighted that understanding student motivational needs is the first step for addressing student engagement in mathematics. Secondly, developing a wide repertoire of practices that tap into students’ internal needs is crucial for promoting long-term emotional and cognitive engagement in mathematics (Skilling, 2014).

REF4 made the following assertion from daily observations of students. “What I hear from a student is that there is the excitement when they can make a connection from something, we have shown them in one context to something else.” Students seem to have academic buy in when there is an internalization of the problem or question that needs to be answered via STEM. Participant REF3 went further to describe this engagement as a desire to know more. “The
students have a desire to want to know more or have the opportunity to use this opportunity to solve whatever the problem is.”

Problem-solving was reiterated by participant REF5 who indicated that there was a definite interest in practicing those skills where there is a deficit when attempting to justify or solve engineering design task. "I have some students who do not like the building portion, but they love the design process. They love just thinking about the actual product and like drawing it out and writing to explain the purpose behind each design decision."

Participant REF1 noted that there were, in fact, opportunities through STEM that allowed for the multiple intelligences of students to be leveraged in order to master tasks. This requires those academic skills that was in some cases difficult to manage. The participant also noted that the use of STEM allowed for bridging one subject to the next and creating transferrable skill. "Students that are interested in drawing and the arts, really embrace the sketching and brainstorming parts to the engineering design process. Students who enjoy social studies and English, appreciate the research, reading and writing and students with strength in math enjoy collecting data and data analysis and are willing to do it." Detailed coding is provided in Table 4.3.
Table 4.3

*Data Sorted in levels for research coding Q2*

**Question two: Has STEM been used to help develop these skills?**

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<thead>
<tr>
<th>Raw Data</th>
<th>Open Coding</th>
<th>Axial Coding</th>
<th>Selective Coding</th>
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<tbody>
<tr>
<td>I think the number one benefit that we've seen with our STEM approach has been engagement and perseverance.”</td>
<td>STEM instruction creates continual engagement. Students have a desire to engage in the learning processes when there is an immediate use of the knowledge.</td>
<td>Students have a desire to engage in the learning processes when clear connections can be made. Students find STEM learning opportunities relevant and applicable.</td>
<td>Consistent interaction with foundational skills, is a constant when introduced with STEM. It is evident by the increased perseverance in those areas of greatest need such as creativity, analyzing and problem-solving.</td>
</tr>
<tr>
<td>“What I hear from a student is that there is the excitement when they can make a connection from something, we've shown them in one context to something else.”</td>
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<tr>
<td>“The students have a desire to want to know more or have the opportunity to use this opportunity to solve whatever the problem is.”</td>
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<tr>
<td>“So. In my class the way skills are kind of developed is through talking and using the engineering design process and one of the most important parts of it are the like redesign and rebuild.”</td>
<td>Students are readily engaged in developing skills through project-based learning, with STEM processes such as the engineering design process.</td>
<td>Consistent exposure to the skills through STEM driven task is gives much needed practice in foundational areas, under the guise of STEM.</td>
<td></td>
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<tr>
<td>“Students engage in projects for up to 6 weeks which make them continually engage in the process of reading and analyzing to get to the solution.”</td>
<td>Extended amounts of time practicing those necessary foundational skills.</td>
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</table>

Students are readily engaged in developing skills through project-based learning, with STEM processes such as the engineering design process. Extended amounts of time practicing those necessary foundational skills.
STEM’s Influence on Student Thinking

Another node that the researcher investigated was the integration of STEM curriculum on student thinking. The researcher specifically wanted to determine if any discernible attributes were noticeable when students were immersed in STEM learning. The participants provided observations, trends, and in some respect connected each of the strands back to student thinking. This included ability of students to think their way through the task, questioning the reasoning of others and recognize misconceptions in their thinking when working with a difficult task.

During the interviews, the impact that STEM had on student thinking was a distinct change that was visible in student learning. To discern how the students thinking changed, the researcher asked: “How does STEM impact or manifest itself in student thinking?” Participant REF4 noted that, as an instructor, when students are engaged in a STEM learning opportunity, it was obvious how they considered the ways to use skills from various contents to arrive at a solution. “But the challenge itself is not important to me because I want to understand how they are thinking about the task, how they are thinking about a certain problem in math and what solution pathways they come up with and every group is typically different.” The educator also went on to explain how this manifested when students were testing. “Students know if they took a test in my class my test would be a test that makes them consider what they need. Which makes them realize that they have to use their knowledge available or what are some constraints I need to consider and to work around it.”

When considering the students that have and have not been exposed to STEM opportunities, REF5 noticed a viable difference in the performance of students in their class, and the cognitive ability slowly but surely changed over the semester. “Students that are taking the
STEM course can kind of think outside the box and try to invent different ways to find out different things or come up with different solutions and the same students seem to, think through the process a little bit more, than the students who do not attend STEM. So, they feel that they have more of an ability to get through some of these tasks.”

Metacognition of students was a significant watershed on how the use of STEM as a foundation of learning made students develop their abilities to think across content areas. REF5 furthered the impact of STEM on students by explaining more of the structure that STEM brings to students allows them to think deeper. “I think critical thinking and that goes back to, not always giving the answer and they can try to figure out what the answer is using their methods their prior knowledge their own. The information then maybe they have learned from home or in other areas. So, I think STEM does help them develop those critical thinking skills. To where they can create a process for themselves to solve problems or analyze information.”

The theme of critical thinking also began to emerge from the research, as the interviews with the population of teachers continued. Participant REF5 immediately noted that students that were exposed to the STEM program at their school showed a maximum or increase in abilities to think critically. “I will say that I think that they have groomed their ability in critical thinking and independent learning in the STEM class that is transferred over to the normal science course.”

What was also revealed in the interviews was that the use of these skills was essential for students to start to transfer this knowledge from one content area to the next. REF3 stated that there was an opportunity with STEM to make students aware of the importance of knowledge and how it is not siloed from one area to the next. The critical thinking abilities of students are
created and prompted by having experiences that allow for all skills to be used to focus on a topic of interest. “So when we talked about STEM, it was a way of not only doing it better, but to do it more thoroughly and do it more quickly because when the kids get it the first time they don't have to go back and do a two three four times like you have to do now because they didn't care about it in the first place. STEM makes thinking more fluid as well and, in a sense, deeper because they will generate new ideas.”
Table 4.4

Data sorted in levels for research coding Q3

Question three: How does STEM impact or manifest itself in student thinking?

<table>
<thead>
<tr>
<th>Raw Coding</th>
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<th>Axial Coding</th>
<th>Selective Coding</th>
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<tbody>
<tr>
<td>But the challenge itself isn’t important to me because I want to understand how they’re thinking about the task, how they’re thinking about a certain problem in math and what solution pathways they come up with and every group is typically different. Students know if they took a test in my class my test would be a test that makes them consider what they you need. Which makes them realize that you have to use your knowledge or what are some constraints I need to consider and to work around it.”</td>
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<tr>
<td>STEM engages students at a level of thinking that can be tracked, through a tangible product.</td>
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<tr>
<td>STEM allows students to revisit their thoughts by surveying their products or forms of data tracking.</td>
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<tr>
<td>STEM provides consistent opportunities to revisit ideas and make changes to tangible products that are a result of these ideas.</td>
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<tr>
<td>STEM has a discernible impact on students’ willingness to develop various ideas and processes to solve problems and critique the thinking of others. STEM curricular allows students to effectively use their knowledge across content areas seamlessly to garner and create new information.</td>
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</table>

“So when we talk about STEM it was a way of not only to do it better but to do it more thoroughly and do it more quickly because when the kids get it the first time they don’t have to go back and do a two three four times like you have to do now because they didn’t care about it in the first place. This makes the thinking more fluid as well and, in a sense, deeper because they will generate new ideas.”

“Students that are taking the STEM course can kind of think outside the box and try to invent different ways to find out different things or come up with different solutions and the same students seem to, think through the process a little bit more, than the students who don’t attend STEM. So, they feel that they have more of an ability to get through some of these tasks.”

“I think critical thinking and that goes back to, not always giving the answer and they can try to figure out what the answer is using their own methods their own prior knowledge their own. Information then maybe they’ve learned from home or in other areas. So, I think STEM really does help them develop those critical thinking skills. To where they can create a process for themselves to solve problems or analyze information.”

“I will say that I think that they have groomed their ability in critical thinking and independent learning in the STEM class that is transferred over to the normal science course.”

“Critical thinking skills are refined and improved with STEM content as conduit of learning.”

“Through STEM students have autonomy of how to create processes for growth.STEM provides critical thinking practice for students in all content areas."
Transferable STEM Skills

As the interviews continued, a clear connection between students being able to think and therefore transferring that knowledge to other aspects of their learning was noticed. As noted in the hierarchy chart (Figure 4.2), there is a clear connection between student thinking and transferring that knowledge to content areas beyond STEM. As indicated in the hierarchy chart there is a clear connection between transferable skills and student thinking. It was important to understand what led to such a strong connection between critical thinking and transference of skills. The researcher sought to understand better how students were able to transfer skills from the experiences designed around STEM to content area classes. “What skills are easily transferred from STEM opportunities to content area classes?”

Figure 4.2 Hierarch Chart of Research Nodes
From the interviews with the participants, the researcher was able to understand why students, under the guise of STEM, were able to transfer skills from STEM to other areas readily. One area that the participants believed was transferrable was the processes that are commonly used in the STEM which included engineering design, scientific method or creating multiple routes to solve mathematics task. Some of the participants provided first-hand examples of how these skills applied to learning and experiences outside of the classroom, therefore allowing students to make intrinsic personal connections. REF1 pointed to the fact that in class, students can be seen making these connections. “I believe that the idea of testing a solution and innovating your ideas can be transferred to all classes.” This level of ease in which these students are willing to test these ideas is made possible because STEM gives students the freedom to fail but also attempt new ideas and understandings. “Students understand in STEM that it is ok to fail. Failure is the motivation to keep trying new things until you get the best outcome that you can achieve.”

REF2 provided examples of how students involved in an afterschool STEM program brought the skills into the classroom. Which exemplified what STEM as a foundation of learning and provided a visual of what STEM learning looks like. “Students, who are in this program, are often given the experience of mathematics just by them building a wheel for a race car, which they did not realize that they were using geometry until they enter math class. When they return to their math classes, and they are like oh my wheel was a circle. How did I measure this wheel? Did I use circumference, diameter or radius? So those were things that they learned in their STEM lab using manipulative that have now transferred back into their core concept classes which makes the real-world connection which makes learning a little bit more not only kinesthetic, but it makes it sticky.”
Some of the participants even connected the use of critical thinking skills that were spawned from STEM-based learning opportunities to the transferring of knowledge from one content area to the next. REF7 made the following assertion when asked about STEM and the transfer of skills. “One skill I would say that is transferable can read and interpret graphs, charts, and tables. Although this was an academic skill student need to develop it becomes easier for students to understand and therefore practice by connecting it to an application problem.”

REF5 noted the following from the experience of teaching students actively enrolled in a STEM program: “I think critical thinking is transferable, and that goes back to not always giving them the answer, by making them try to figure out what the solution is or could be by using their method, engineering design process, or discussing with others they can easily transfer these skills from subject to subject.” REF3 added to this theme of transferable skills by introducing the idea of perseverance. “With STEM as a foundation of learning students learn how to preserve in challenges, which is a skill.”
Table 4.5

Data sorted in levels for research coding

What skills are easily transferred from STEM opportunities to content areas?

<table>
<thead>
<tr>
<th>Raw Coding</th>
<th>Open Coding</th>
<th>Selective Coding</th>
<th>Axial Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;I believe that the idea of testing a solution and innovating your ideas can be transferred to all classes.&quot;</td>
<td>There is the ability for students to transfer the skills of experimentation to content classes.</td>
<td>The use of STEM changes the learning environment for students to feel secure in rethinking, redesigning and building capacity in content areas.</td>
<td>STEM provides experiential learning that creates a safe space for students to develop their skills in critical thinking, analyzing and perseverance in task. The way in which learning opportunities are structured in STEM create an access point for all learners to retrieve content knowledge as well.</td>
</tr>
<tr>
<td>&quot;Students understand in STEM that it is ok to fail. Failure is the motivation to keep trying new things until you get the best outcome that you can achieve.&quot;</td>
<td>STEM provides the opportunity to restart or redesign ideas, after failure without any consequence. Builds students stamina to develop and discover multiple solution paths.</td>
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<tr>
<td>&quot;I think critical thinking is transferable, and that goes back to not always giving them the answer, by making them try to figure out what the solution is or could be by using their own method, engineering design process, or discussing with others they can easily transfer these skills from subject to subject.&quot;</td>
<td>Real time experiences that derive from STEM make content and its uses available when revisited later in course work.</td>
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<tr>
<td>Students, who are in this program, are often given the experience of mathematics just by them building a wheel for a race car, which they didn’t realize that they were using geometry until they enter math class. When they return to their math classes and they’re like oh my wheel was a circle. How did I measure this wheel? Did I use circumference, diameter or radius? So those were things that they learned in their STEM lab using manipulative that have now transferred back into their core concept classes which makes the real-world connection which makes learning a little bit more not only kinesthetic, but it makes it sticky.&quot;</td>
<td>Skills required to proceed through STEM task, such as analyzing real time data are relevant to their success in other courses.</td>
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<tr>
<td>&quot;One skill I would say that is transferable is being able to read and interpret graphs, charts, and tables. Although, this was an academic skill student need to develop it becomes easier for students to understand and therefore practice by connecting it to an applicable problem.&quot;</td>
<td>STEM skills are easily transferred from experience to content. Introduces necessary skills by real time application.</td>
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</table>
Focus Group

A small focus group was formed consisting of three of the seven teachers that were interviewed. There were specific questions for this group to help specifically focus on the ideas behind the use of STEM for education. This group was created to ensure validity in the findings in the original study. The following questions were used to guide the conversation: 1. Is there a viable change in students’ abilities in core academic areas after exposures to STEM? 2. With STEM as a platform do you notice all students finding different ways to access content knowledge? 3. When engaged in STEM tasks are students able to make connections to their core subjects and over time able to iterate these examples over under different circumstances?

The method is particularly useful for exploring people's knowledge and experiences and can be used to examine not only what people think but how they think and why they think that way (Kitzinger, 1995).

Teachers agreed that students’ abilities would be difficult to measure without some quantitative and standardized assessment. However, referring to the previous individual questions, they all considered how the process of STEM could influence students to think critically when given a multistep task. STEM provides them practice on how to use knowledge from various contents to approach the task.

REF5 participant stated that using phenomena in STEM gives students a place to start. “Kids that I see exposed to STEM do not immediately say “I do not know how to do this.” They can at least start a task and have something to show, and to consider if they are going in the right direction with their thinking.” The group also shared that this would take longer, more consistent studies before an assertion could be made that student abilities were changing and for
them to interact with content and succeed through it using STEM as the foundation. The ability to access content was an underlying focus of the research. The participants in the focus group were asked to determine whether STEM gave students the ability to access knowledge at different points in a task. REF7 agreed that because there is so much overlap when using STEM, that students exposed to this process of thinking could better connect the dots when learning. “I think overall it helps them connect the dots and have a better understanding of the materials.” Coding this brought attention to the idea of REF2 participant who described how students used their experience of building a race car then assisted with their understanding of circumference.

The focus group also noted that the use of STEM and in some cases, STEAM gave many students a draw or interest in this REF1 participant referred to a previous statement in which they describe how to use the Art in STEAM engaged students that would be good at creating diagrams that would then lead them to focus in or refine their knowledge of dimensions or measurements which are geometry concepts. These experiences also extended to them understanding how to incorporate skills that span from one subject to the next.

Summary

The data presented in this chapter were collected from three urban schools in the Middle, West, and East Tennessee area. Each educator has worked in their respective districts for at least a year and is very familiar with the STEM initiatives in each area. Each educator works in a STEM school, STEM-related subject area or is a STEM educator. The focus group was essential as these teachers would be able to recognize them and identify the influences of STEM education easily. Interviews were completed in person, via phone or zoom conference.
CHAPTER V

Conclusions, Implications, and Recommendations

The idea of STEM education has been gaining ground rapidly across the country and the world. However, there is no exact definition or idea of how STEM as a foundation of learning should look in a classroom and there is minimal research on how this impacts students for generations to come. Continued implementation of this initiative is needed to further the education communities.

The purpose of this study was to acquire feedback from educators that currently work in STEM in some capacity at the elementary and secondary level. Having feedback from professionals would allow the researcher to have observations that attest to the influence of STEM education on student’s ability to think critically, make cross-curricular connections. Seven teachers were interviewed individually, using semi-structured interview questions while more specific structured questions were used with the focus groups to summarize and validate the overall discussion that occurred with each teacher.

The interviews were audio recorded and the data was coded into five topics: academic skill development, developing skills with stem, engagement in class, student thinking and transferrable skills. The data were analyzed to determine which node seemed to be the result of using STEM as a foundation of learning: What are the designated differences educator see who have experience working in traditional settings when STEM is introduced as the basis of learning?
This chapter provides a summary of the statement of the problem, discussion, conclusions, implications, and recommendations. This chapter also includes the implications of the study and recommendations for further research.

**Statement of the Problem**

STEM education is slowly gaining ground to help educate students for the 21st century. However, there is minimal research provided to explain the patterns or critical thinking skills development that students receive with STEM as a support for learning. Although there is some available research on STEM, there is very little that speaks to understanding what skills students and educators stand to gain with STEM implementation in core content areas. With the lack of formal written research on how STEM can influence students thinking across contents, the effects on stamina when it comes to completing a multistep task are unclear. This study sought to determine how teachers could see students’ progress in other areas when there was specific instruction using STEM-based curricular or models.

**Discussion**

Regarding academic skills students needed to develop, the teachers often spoke of students needing to develop abilities in literacy, comprehension, analyzing, creativity and critical thinking. Teachers expressed that all though some of these skills were not easy to assess with any test, these were crucial skills to just accessing the knowledge needed to achieve. They pointed to the constant struggle that students have being able to comprehend information that is presented in exoteric manners if there is no point of reference, that compensates for the lack of specific skills. According to participants, STEM was beneficial in the sense that it provided more points of entry for students; it also engages them in learning opportunities that practice these skills.
The continued engagement was also another idea that each teacher expressed in the interviews and the focus group. Because STEM blends seamlessly with every subject, students were more likely to be engaged, as there was an opportunity with each STEM-related task for students to be responsible for the learning. Teachers noted that the students were able to use the most robust multiple intelligence to demonstrate that knowledge adequately. As for the students meeting set standards that also occurred as students have a real-world reference that covers all standards across all content areas, which speaks to the students understanding how to transfer skills or process from one area to the next.

Teachers continually returned to the idea of what it means to think critically and that this was at the heart of STEM education. The press for students to have some ability to think beyond what is presented to them or have them create new pathways of thinking was critical. Some of the educators alluded to the fact that without critical thinking skill there would be no way for some students even to enter a task accurately. Critical thinking skills attributed to a math or science class could now be integrated into English to assist students with understanding the various form of writing as well as meshing the two worlds of mathematics and English together when students are asked to justify understanding or explain the reasoning behind how some problems in mathematics are solved.

Finally, teachers agree that the use of STEM should be implemented in every content class and the benefits of this multi-content area are the enhanced ability of students to think critically and creatively are vital to enhancing future academic growth. To the extent that the class reflects the use of all other subjects. With the goal being that teachers and students can actively engage in the knowledge at any point during a lesson. There was also a keen emphasis on student engagement which is considered a fundamental need in order to move thinking ahead
in any K-12 classroom. There is still a long way to go in order to see students make new conceptions of their learning, which was suggested will start to happen over a more extended period with fidelity and implementation of STEM as a system of learning.

**Research Question**

What are the designated differences that educators, who have experience in traditional education settings, see when STEM is incorporated as the basis for learning? The study gathered information from seven teachers working in STEM schools and traditional schools with STEM programs in Middle Tennessee, West Tennessee and East Tennessee area and collected teacher observation of students’ academic growth or adjustments. Two emerging concepts form this study are the importance of transferrable skills and student thinking.

When discussing transferrable skills, teachers referred to the use of STEM as an access point that introduces skills in an engaging manner that allows instructors to track student thinking and make critical thinking a crucial part of student performance across the board. The findings were explained in Chapter Four, which states that STEM drives students’ abilities to think critically, problem solve, develop processes to solutions and transfers skills from one content area to the next. According to teachers, universal themes that were found in the implementation of STEM as a foundation of learning include: engagement, creating different entry points to various learning, intrinsic motivation to reach a solution, develop skills, integrate every content subject and make clear.

**Conclusions**

The data collected from research build a foundation that supports the use of STEM for cognitive, academic and skill development. Educators have identified transference of skills and academic skill growth as the primary benefit of STEM. In the hierarchy of learning, these two
areas are directly correlated to engagement, which was a sub-code that developed after multiple interviews with educators. Engagement through STEM creates a new entry to learning, which is essential when students may not possess enough foundational skills to begin the process of finding solutions. Participants indicated that students can ask questions using their funds of knowledge and then find a process using those transferable skills from STEM to make connections that are not only standards-based but assist in cognitive growth or academic perseverance. Having a definite use for STEM is not always easily identified in every content area unless there is a concerted effort by the school community to embrace the pillars of STEM as a method of instruction.

**Implications**

In order to have a more generalized understanding of how STEM is experienced across content, it would be essential to replicate the study with a larger pool of teachers working in different content areas. The research would also include looking at more non-traditional academic environments that have STEM learning opportunities. A qualitative study was essential to start the discussion on STEM education and determine if any correlation exists. However, there would need to be more qualitative data collected to document how students are showing concrete, measurable changes in skills. New research could include results from the standardized test but also alternative assessments that are used.

Finally, the goal of this study was to identify to document the differences that teachers teaching in traditional school settings can observe when STEM is integrated seamlessly into the curriculum. These interviews should also include some data collected from students as they illuminate how they experience STEM.
**Recommendations for Further Study**

This study took place at four different schools encompassing West, Middle and East Tennessee and included public and public charter schools. Expanding the scope of the research to involve more schools would be a natural progression. This expansion should also include varying types of school from elementary to high school. By doing so, researchers could monitor students’ progress among students who remain in STEM environments versus those that may opt to attend traditional learning institutions without STEM opportunities.

Researchers should also compare the expenditure for Lead Education Agencies to fund STEM programs in large and small districts fully. Developing a cost-benefit analysis can assist with the decision-making process to offer some level of STEM education in our local schools. Also, while examining these different school communities, keen focus should be placed on how misconceptions are developed based on the resources available for proper STEM education. Can the question be posed that all teachers should be trained to be STEM teachers? If so, is there a correlation between the uptake of new skills and STEM and teacher preparation?

Finally, researchers should then look to determine what the long-term implications of STEM learning could be. How would this data collection look? How long will it take to collect such long-term data? What are the next steps to fully explain to the community the need for STEM education? What is the overall impact of this on the surrounding community?

**Conclusion**

The research has stated that there are discernible differences in environments where STEM education is integrated into the learning. Educators observe these by the academic and transferable skills that students, exposed to STEM, bring with them in content area classes. As students are introduced to learning via STEM, educators are noticing refinement in critical
thinking, solution development, and making cross-curricular connections. All participants identified a renewed engagement in school due to STEM integration in the traditional academic school setting.

Providing more data that speaks to a renewed interest in school that is more quantitative, is vital to further any potential research regarding STEM education. There is the need to expand research to STEMs influence on in traditional, non-traditional, public, charter and private schools. In-depth research will allow for a set of quantitative data to provide to Lead Education Agencies to advocate for STEM for all students.
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Appendix A
Formal Interview Questions
Science, Technology, Engineering and Mathematics: It’s impact on students’ performance in their core courses.

Please provide answers based on your experience’s as an educator in a STEM environment.

Individual Questions

1. What are the common academic skills that students consistently need help developing?

   a. Provide examples of how these deficits manifest themselves.

2. Have you used STEM/or have your students been exposed to STEM as a platform to help develop these skills?
Science, Technology, Engineering and Mathematics: Its impact on students’ performance in their core courses.

3. What are some transferrable skills that are common in science, technology, engineering and mathematics that students apply to learning in other areas?

4. Do students develop new conceptions of learning in core classes using STEM models?
Science, Technology, Engineering and Mathematics: Its impact on students’ performance in their core courses.

5. How do students’ respond to three-dimensional task or learning opportunities after being exposed to STEM?
Appendix B
Focus Group Interview Questions
Focus Group Interview Questions

1. Is there a viable change in students' abilities in core academic areas after exposure to STEM? (i.e. Do students' create multiple routes to solving problems)

2. With STEM as a platform do you notice all students finding different ways to access content knowledge?

3. When engaged in STEM tasks are students able to make connections to their core subjects and over time able to iterate these examples over under different circumstances?