IDENTIFICATION OF ELEMENTARY SCHOOL STEM MODELS

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Abstract

Science, technology, engineering, and math (STEM) education is a growing trend in the United States as a response to a developing need in STEM careers and the United States’ current middle ranking in science and math on the Program for International Student Assessment. This increase in awareness has sparked an interest for STEM integration. Most research regarding STEM integration is focused at the middle and high school levels. Elementary schools are beginning to integrate STEM; therefore there is a gap in research. This phenomenological, qualitative study sought to examine elementary models of STEM integration by focusing on the STEM instruction, assessment, and culture of the schools. The participants included a convenience sampling of teachers in grades K-5, as well as a librarian, from three schools in southeastern Tennessee. A STEM questionnaire, focus group interviews, and artifacts were collected for analysis to determine the models for STEM integration of each school. The theoretical framework from which the data collection tools and data analysis utilized was the Situated Cognition Theory, which posits that learning is solidified and intrinsic when the learning is placed in context, such as an apprenticeship. Three different models for STEM integration were concluded based on the data collected: Directly Integrated Model, Broadly Integrated Model, and Developing Integrated Model.
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Dedication

This dissertation is dedicated to my family…

Johnny- Your understanding of the late nights and hours on the computer were so important to this accomplishment. You encouraged me through my doubts, and I cannot thank you enough for your love. God has truly blessed me to have you as my husband.

Elijah and Emmalynn- Thank you for understanding when Mommy had homework or a paper to write. I hope to be an inspiration to you because you inspire me every day. I will always be your encourager through your lives and your dreams.

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CHAPTER 1: INTRODUCTION

Background of the Study

STEM has recently become a buzzword in education. Like many buzzwords, the meaning can become diluted and its value decreases over time as the understanding of its meaning becomes ambiguous. Science, technology, engineering, and math (STEM) are very specific terms for a concept that is broad and multidimensional. The subjects are connected and build upon each other rather than the perceived silo that is implied by the acronym where the subjects are taught in isolation. It is used to describe careers that involve at least one of the words from the acronym, but even the careers can be unclear in their reference in STEM. STEM careers have an ambiguous identity and are disputable among many educators and professionals. These careers can include computer programming, mechanical engineering, or architecture. However, other careers can be disputed: such as those involving medicine, social sciences, and manufacturing work. The parameters of its definition are not guided by a specific owner of the term; thus individuals form their own perceptions (Gerlach, 2012).

STEM education is a necessary component to the future of a nation as it brings about innovation. It is responsible for producing scientists and engineers that will continue the necessary research for economic growth, developing technologically literate workers to fulfill the growing technical workforce, and creating literate citizens who can critically think and make decisions regarding public policy and global issues (Ehler & Udall, 2008). These components are the responsibility of the education system as the main focus should be to create the necessary workforce for the future.

“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” (Tspros, Kohler, & Hallinen, 2009, p. 35). This definition is vague to those planning for and developing a model for STEM integration in a school setting. This ambiguity stretches into education as schools have begun to implement STEM integrative programs to promote STEM career choices and a level of complex thinking needed for the future workforce (Gerlach, 2012; Breiner, et al., 2012). Diversity among programs brings about issues of fidelity to the STEM initiative, as well as proper designs for a successful program. STEM careers are growing, and schools are striving to meet this demand due to global competition and economy. Programs often define integration as math being a main component of study, science is secondary, and engineering and technology are afterthoughts that occur when there is sufficient time or as extensions for gifted students (Volmert et al., 2013). To combat this ambiguity, more research regarding the definition of STEM models in education needs to be conducted so that STEM preparation can progress.

Research Problem

There is a lack of research surrounding the STEM models utilized in an elementary school setting. This study sought to examine the variety of STEM models among schools with a STEM initiative in place to fill the gap. Common themes for integration were evaluated to determine a consensus for a typical STEM integrated program in an elementary school setting. Minimal research has been conducted regarding elementary school STEM initiatives. The information gained from the study will aid other prospective STEM schools as they strive to build their programs.
Purpose of Study

Elementary school STEM integration is often a vague concept without defining parameters or models. Models need to be defined for the usefulness of others and for the success of programs. This research was unique due to its focus on the elementary school setting. The majority of the existing research for this topic relates to middle and high school programs. This study could also contribute to the field of research regarding integrative studies and program implementation.

Research Question

What models for instruction, assessment, and culture are elementary schools utilizing to implement STEM integration?

Rationale for the Study

"Economic projections point to a need for approximately 1 million more STEM professionals than the U.S. will produce at the current rate over the next decade if the country is to retain its historical preeminence in science and technology” (Xue & Larson, 2015, p. 1). Today’s schools need to reflect such research-based change. STEM education has become a focus for many middle and high schools; however, elementary education has not made such a shift (Bencze, 2010). Because there is a lack of elementary participation, minimal research has been conducted for this level of instruction.

The elementary school setting is different from its middle and high school counterparts due to the nature of the setting. Elementary schools traditionally have self-contained classrooms in which the students have only one teacher who is responsible for all subjects. Middle and high school settings contrast because the students change classes and teachers for each subject. Thus, the model of STEM integration would naturally be different. Models need to be identified to add
to the body of research so that the process of implementation can occur more smoothly for those who are planning to implement a STEM integrative program. Identification of models will narrow the definition of integration to allow schools to have a precedent for success. This research is also critical to the STEM pipeline for the middle and high school levels. The culture for developing STEM minded students would become more consistent due to the students’ exposure to STEM thinking and skills at earlier ages in elementary school. The culture will allow for middle and high school teachers to begin their teaching of STEM from a more advanced level because of the incurred background knowledge. Students need to be adequately prepared for each level of their education, and without the appropriate elementary level implementation this need will not be met.

**Limitations and Delimitations**

In examining limitation, biases and preconceived notions about practices and strategies based on prior experiences were acknowledged as not to influence any themes or perspectives. Another limitation is the scope of the study. There were few STEM schools to be considered during the study due to proximity. Delimitation to the study is the use of schools that are not STEM-certified through an outside agency. Those certified would fit specifically to a designed rubric; thus their model would be influenced by this design rather than their own vision.

**Researcher Positionality**

The researcher, who holds a master’s degree in education and an educational specialist degree in administration, has 10 years of experience in an elementary classroom setting. In addition to teaching, the researcher has been the STEM coordinator for the school for three of those years. As both a classroom teacher and STEM coordinator, the researcher derived significant knowledge from a variety of experiences including STEM fellowships at the local,
regional, and state levels. The researcher toured numerous STEM schools, and the information gathered has been used to develop the STEM program of the researcher’s school. The researcher’s role in the study included the collection of data and determination of the models utilized in STEM schools. The researcher utilizes a specific model in the classroom and has gathered model components from other STEM schools.

Definition of Terms

1. Science- the seeking of understanding and application of knowledge of the natural world through strategic methods (Science Council, 2017)

2. Technology- the use of products, process, and materials for the realization knowledge (Leonard, 2015)

3. Engineering- the profession that uses math and science to develop materials (Accreditation Board for Engineering and Technology, n.d.)

4. Math- the study of numbers, shapes, quantity, and space as they are related (National Council of Teachers of Mathematics, 2017)


6. STEM integration will be defined as the merging of the disciplines of science, technology, engineering, and mathematics in order to: (1) deepen student understanding of each subject through real world contexts, (2) exposure to and the building of college and career readiness skills, and (3) increasing the interest in STEM fields due to the influence of materials and experiences (Moore, 2008).
Summary

STEM education and integration is becoming a well-known concept that is being utilized in many different contexts. The ambiguity of the concept has led to a lack of focus and direction for education and career disciplines. It is important that a consensus is built around its definition and implementation to ensure the quality and outcome of the program are successful. The evaluation and defining of different STEM models within a school setting will allow for a firmer definition and guidance to those who seek to integrate. In this study, the researcher identified the thematic components of STEM integration in terms of instruction, assessment, and culture of the elementary schools included in the study.
CHAPTER 2: REVIEW OF LITERATURE

History of STEM

The National Science Foundation originally developed the integration of science, math, engineering, and technology (SMET) with a focus on critical thinking in the 1990’s. Later, it transitioned to science, technology, engineering, and math (STEM). Although STEM was being utilized for business, it was not being utilized in education (Sanders, 2009). Numerous events served as catalysts to the United States’ interest in STEM, beginning with the Morrill Act of 1862, in which land grands were disseminated for agriculture and later used for engineering training programs. Other historical events include Sputnik, the atomic bomb, and inventions created during World War II (White, 2014). This generated a national motivation to compete with other countries in science and innovation.

Notable inventors such as Thomas Edison and Henry Ford were not distinguished by their educational accomplishments, but utilized apprenticeships to enhance their knowledge base. These apprenticeships utilized STEM principals of collaboration, critical thinking, and problem solving that allowed them to become successful (Butz et al., 2004). However, STEM as an educational focus did not exist during this time. Situated cognition was utilized, which developed Edison and Ford through the experience of learning rather than the dissemination of knowledge (Brown, Collins, & Duguid, 1989).

More recently, President Barrack Obama began a STEM agenda in his “Educate to Innovate” campaign and the Prepare and Inspire report (whitehouse.gov, 2009; Bybee, 2013) to encourage youth to seek STEM-related fields in education due to the nation falling behind many other countries on the Program for International Student Assessment (PISA) in science and math (Russell, Hancock & McCullough, 2007). These recommended that 100,000 new STEM teachers
be trained in the next 10 years, a STEM Master Teacher corps be created, the number of STEM-focused schools be increased, and after school STEM programs be provided. Russell (1999) noted that the most opportunistic time to inspire interests in science and math is in elementary school. Due to standardized testing, science, engineering, and technology are often put aside to focus only tested subjects through a traditional method. STEM integration would require a focus on all subjects (National Education Foundation, 2017).

21st Century Workforce Skills

Upon graduation from high school, students are to be equipped with the workforce skills necessary for the 21st Century. Numerous businesses have identified skill sets that are needed if workers are to be competent and skilled. It is important for schools to strive to meet this demand to ensure the United States can supply the needed workers rather than outsourcing the jobs to people from other countries (Apte, Karmarkar, & Nath, 2008).

Wagner (2008) identified seven skills that students should master in order to be successful in the job market. These skills include: critical thinking and problem solving, collaboration and leadership, agility and adaptability, initiative and entrepreneurship, oral and written communication, accessing and analyzing data, and curiosity and imagination. These skills were deemed to be in the future work force as the next generation will play an important role in making social, economic, cultural and political decisions.

A majority of companies report difficulties in finding capable and qualified employees for positions with which there were openings (Manyika et al., 2011). This demonstrates the discrepancy between the preparation of the nation’s population and the skills needed by employers. It is also reflected in the disparity displayed in the unemployment rates as opposed to the number of job openings. In 2017, there were two unemployed workers for every job vacancy
in the United States (Bureau of Labor Statistics, 2017). Many of the vacancies were due to the inability to find applicants with the technical expertise and strong workplace skills (Manpower Group, 2011). This may be due to the incongruence in what students are expected to learn and what schools are expected to teach. The narrowing of the curriculum disallows for the teaching of the necessary skills of a 21st Century workforce. Teachers are feeling pressured to teach the prescribed standards and perform well on standardized testing. This arrangement is not conducive to skill development (Burrus, Jackson, & Steinberg, 2013).

Between 1967 and 1997, the workforce dynamic changed from a material economy to an informational economy (Apte, Karmarkar, & Nath, 2008). In the 1960s, a majority of the production was due to material production, such as cars and construction. Currently, the majority of production focuses upon informational services or products such as phones and computers. This shift in focus requires a change in workforce readiness skills. The retirement of many ‘baby boomers’ has also led to labor shortage (Delano & Hutton, 2007). The global economization of the job market has increased the competitiveness for workers (Morrison, 2008). This necessitates the importance of 21st Century workforce skills.

Burrus, Jackson, and Steinberg (2013) defined 21st Century workforce skills as the qualities that influence a worker’s performance and his/her ability to acquire new knowledge and the necessary skills to be an effective worker. Studies have identified specific skills that are becoming crucial in the labor market including: adaptability, collaboration, problem solving, self-discipline, written communication, leadership, professionalism, creativity, and critical thinking (National Research Council, 2011; Conference Board, 2006). Depending upon the nature of the job, each skill may be more or less important. However, schools need to develop all skills in order to better prepare students for the job market.
The Tennessee Department of Education (2017) conducted a study of over 225 stakeholders in a series of focus groups. Participants were asked about the necessary employability skills in today’s workforce. Four primary categories were identified: application of academic and technical knowledge and skills, career knowledge and navigation skills, 21st Century learning and innovation skills, and personal and social skills.

The application of academic and technical knowledge and skills components consisted of the comprehension of necessary materials that are relevant to the job, the application of math concepts in the contexts of the occupation, and possessing industry-specific technical and safety skills. The career-knowledge and navigation skills component included the understanding of career paths according to personal aspirations along with the planning of the goal and the ability to reflect on the goal through a personal portfolio. The 21st Century learning and innovation skills component encompasses creativity and innovation, critical thinking and problem solving, communication, collaboration, the management of information and technological literacy. Necessary personal and social skills identified were the willingness to take initiative, professional attitude and responsibility, cultural sensitivity, flexibility, and productivity. The two most important skill sets identified were the application of academic knowledge and skills and personal and social skills (Tennessee Department of Education, 2017).

Adaptability, communication, problem solving, and self-management were most commonly discussed as important 21st Century skills needed for future workers (Tennessee Department of Education, 2017; National Research Council, 2011; Conference Board, 2006). Adaptability is the ability to change based on new circumstances or experiences. Adaptability includes coping with stress, different personalities, cultures, and situations. Effective communication skills are both verbal and nonverbal. A good communicator can convey an
appropriate message through body language, voice, and emotion with a positive outcome. Individuals need problem solving skills so that they are able to acquire all of the necessary information on a topic and come to an effective and strategic resolution. These individuals move beyond the identification of the problem and are solutions-oriented. Metacognition is an important aspect of problem solving. Self-management is the ability to work independently with the drive to complete a task, as well as the willingness to acquire new information when necessary to be successful. These skills have been included in multiple studies as a top priority for businesses in hiring skilled workers; thus it is critical to the goal of education that the skills are nurtured and developed throughout a student’s academic career to ensure success for post-secondary endeavors (Bevins, et al., 2012).

These skills should be enhanced through education. Education and training are necessary to adjust to changes in technology and advancements in the future job markets (Organization for Economic Co-operation and Development, 2010). This is the development of human capital. The goal of education is to develop “autonomous, flexible, creative, and responsible agents of change in response to the educational challenges of the day” (Van der Linde, 2000, p. 702). Many can be developed in core educational subjects such as literacy and mathematics. Students can learn these skills through problem and project-based learning in which they collaborate to solve an issue. Teachers need to be explicit in their instruction of the skills rather than solely focus on the content, but both should be emphasized. Students need to experience innovative thinking and ill-defined tasks where there is no right or wrong answer. By structuring lessons around concepts to be taught with the use of 21st Century workforce skills as a conduit, the learner is more likely to use the new knowledge in a more flexible manner. This type of
instruction is multifaceted and allows for a deeper understanding of the content as well as develops the necessary skills for the student’s future (Bevins, et al. 2012).

Variations in STEM

Since STEM became a meaningful educational initiative, there have been variations added to the term. The addition of the arts was included to create STEAM and reading has most recently been added to create STREAM (Science, Technology, Reading, Engineering, Arts, and Math). The intention of each is to implement the additional component in the planning and instruction phase to the STEM curriculum (Freeman, Marginson, & Tytler, 2015).

The concept of STEAM (Science, Technology, Engineering, Arts, Engineering, and Math) is becoming more prevalent as an extension of STEM education. The inclusion of the arts in the acronym and the integration process adds another component to the vision and integration element. The arts have been a much-debated and controversial topic in the United States and have endured numerous budget cuts in various school systems. Due to the rise in STEM interest and funding because of STEM’s impact on the business world and economy, schools are using STEM as a justification for the reauthorization of arts funding by adding the arts component to STEM (Freeman, Marginson & Tytler, 2015). The arts are viewed as a relevant component to STEM because of the creative aspects, which facilitate problem solving and innovation. The addition of the arts has fostered much debate. Some believe the arts helps students to feel less intimidated by STEM subjects. Others believe that the implementation of the arts will establish a precedent that any topic should be included in STEM, which would further dilute its purpose.

The insistence of some groups of teachers and other stakeholders prompted the development of STREAM. This insistence was predicated upon the belief that a literary element is necessary to the success of the whole child. Literacy includes reading and writing. With the
absence of a reading component, some stakeholders are fearful that students will be unable to communicate their ideas in the real world (Furman, 2014).

This perspective is manifested by those that think of STEM as ‘silos’, where each subject is independent of each other. The STEM skills, including communication, are not believed to be taught. This is an example of how the definition of STEM can influence the beliefs and practices of STEM education.

Place Based Education (PBE) is another example of STEM-type initiative. PBE is the creation of learning using the environment. PBE is predicated upon the community resources of the school in partnership so that students learn through the contexts of local real world issues and problems. The community becomes the classroom, and students first examine these issues on a local level before transferring their thinking to a global level. PBE is a learner-centered approach based on the students’ interests. Students use an inquiry process to understand the problems and issues in their communities; then think about how the world works and the challenges in addressing the issue. The students also use design thinking to determine what the current and future states of the issue (Ark, 2017).

PBE compares to STEM education because of its focus on skill building and real world problem solving. There is a collaborative nature to PBE in which students, schools, and communities work together to solve specific issues. Challenges to this approach include rural settings where very few businesses and opportunities exist for partnerships (Tennessee STEM Initiative Network, 2017).

The Design Think Process is a strategy used in the resolution of a problem that utilizes STEM skills and the integration of the STEM components. When approaching a challenge, the first step is to empathize. The goal of this phase is to understand the person’s physical and
emotional states in order to seek an appropriate solution. It is also important to consider what is meaningful to these individuals and how they may view the world. This can be done via observation and communication. Defining the issue, or providing clarity, helps ensure that problems are solved. Clarity needs to be brought to the problem to ensure it is being solved. Information is then synthesized and a clear problem statement is developed. The next step in this process is the ideate phase, in which many ideas are recorded and prototypes are constructed for testing. This is similar to the scientific method. Utilization of both imagination and the rational mind are important during this phase, and this phase correlates with the problem-solving and creative component of STEM integration.

Design thinking is often a strategy that is considered to be associated with STEM. When conducting design thinking, STEM integration also occurs due to the skills being used and the real world relevancy of the work being done (Plattner, 2010).

**Problem/Project Based Learning**

Problem and project-based learning (PBL) is a strategy of teaching that allows students to learn content through an open-ended problem in a group setting. These students learn through trial and error as well as by ‘doing’. The content is not taught explicitly before the lesson; rather the goal of the strategy is for the students to develop the necessary understanding through the process of problem resolution. The students are asked examine the issue and consider their background in it. Once they are aware of their lack of knowledge relative to the problem, students are required attain the necessary information through relevant resources, such as technology or professionals in the field. Next, they determine possible solutions to the issues and any subsequent consequences for each solution path. Then, students decide on the most appropriate solution and present their results. Students explain what they have learned and the processes they used to develop solutions. These projects can be short-term or long-term
depending on the age of the students and/or the goal of the learning. There is an applied use to the information that is practical and relevant (Cornell University, 2017; Merrit, et al., 2017).

Project-based learning and problem-based learning allow for the development of various skills that are reflective of college and career readiness. Students become experienced in collaboration and holding leadership roles. They are forced to work together throughout the process as each person is responsible for certain aspects of the project. Students must communicate clearly; both verbally and through writing. They must display their ideas to each member of the team as well as to an audience interested in the results. Critical thinking and problem analysis are evident in this type of learning (Akınoglu & Tandoğan, 2007).

Because the problems are ill-defined, students have to define the problem or issue in many ways to determine its many facets. Without structuring the problem, a thorough and relevant resolution will not be determined. Students must apply previous knowledge from personal background and content knowledge to the issue at hand. They practice research skills to learn the needed content, which also requires self-pacing. The teacher is not leading each step in the process; thus the responsibility of ensuring the project is complete is reliant on the student. Dependent upon the student’s age and maturity level, the teacher may offer more or less guidance to ensure the focus and direction of the project is progressing. Students in middle school and high school are typically given ill-structured problems in which they must identify the problems or issues in the case study. Elementary students are provided more guidance in the beginning of lesson. The problem may be more specifically stated so that the students’ focus is appropriate for learning (Merritt, et al. 2017).

Students must also use information across disciplines. While the content focus may be limited to one subject, to effectively come to a resolution, the students use knowledge from other
subjects (Nilson, 2010). Student motivation, conceptual understanding, and attitudes are positively affected by the use of problem and project based instruction (Potvin et al., 2011).

The assessment of problem and project based learning is challenging and often a reason for teachers to avoid using the strategy (Bartholomew, 2017). The subjective manner for assessing can be discouraging. The students’ grades can be dependent on the teacher’s background, experience in the topic, fatigue levels, etc. There is disagreement on a cohesive and reliable assessment for the results or products of an ill-structured problem. The outcomes can be very different without an actual correct answer to issue. The outcome is dependent on the student’s background and experiences as well as how well the students worked together. Most often, teachers use rubrics and a portfolio system to assign a grade for lessons and learning. However, even with rubrics, teacher bias continues to be a part of the assessment.

Teacher reflection is critical to validate the assessment process for problem and project based learning. Reflection causes the teacher to consider their biases, as well as how grading is occurs. A teacher may determine if he/she is grading too strongly or weakly as the projects are evaluated (Bartholomew, 2017). This type of strategy is called Adaptive Comparative Judgement, which creates a winner and loser (Pollitt, 2004; Kimbell 2007). The projects are graded in comparison to one another based on strengths and weaknesses. The teacher calibrates the grading as he/she evaluates the results of the students’ work. Final rank order can be used to assign grades. Feedback from the teacher is also important so that the student can understand and reflect on his/her grade in a meaningful way and make future improvements (Bartholomew, 2017).

Project and problem based learning is a strategy utilized in STEM integration. Students participate in cooperative groups with STEM-based problems or issues in which STEM must be
utilized to resolve an issue. Students are able to develop 21st Century workforce skills during a PBL. They must use critical thinking when they analyze problems and seek solutions. Students collaborate in their cooperative groups to research and design a solution. The group uses different disciplines, specific to STEM, to come to a resolution, and they must be able to effectively communicate both orally and in writing with their group members.

**STEM Beliefs and Policies**

Teacher support, level of interest and knowledge, and teachers’ thoughts and feelings are important to the success of any initiative. These aspects factor into the degree a teacher focuses on the planning and implementation of the endeavor, as well as the enthusiasm behind the endeavor. It is critical to understand the beliefs of the teachers to eliminate any misconceptions and to provide the optimal amount of support at the appropriate level (Heath, 2017).

Teachers’ beliefs about STEM and STEM integration is very diverse based on their background, degree, experiences, and colleagues (Thomm & Bromm, 2011). Preservice teachers have developing definitions during their teacher preparation courses regarding STEM integration and its implementation. Many preservice teachers believe that STEM is important, but these teachers feel they lack the confidence and knowledge to practice implementation (Premnadh, 2017).

In a 2011 study of middle school teachers about STEM education, Wang et al. (2011) concluded that many teachers believe problem solving is a main component for STEM integration. Students should be engaged in an issue in which there are multiple paths for a solution. Technology is the most difficult component to integrate into instruction. This may be due to availability of resources or knowledge of technology use. Teachers with background in different STEM disciplines have different perspectives or beliefs on the practices for STEM
integration. Teachers also believe there is a need to include more content into the STEM connections and integration that is occurring.

Teachers are often intimidated by using technology, notably the use of computers, in an elementary classroom; however it is extremely important for students to be exposed to technology at an early age. This allows these students to experience how technology changes over time, evaluate the effects of technology, and use technology in other disciplines. Working with technology not only improves student knowledge of the technology content, but also math and science content knowledge. Becoming adept with technology also helps students develop their problem-solving skills (Hsu, Purzer, & Cardella, 2011).

There is a direct link between the teacher’s knowledge of technology and the student’s knowledge of technology. It is important for teachers to receive research-based professional development on technology integration to increase the proficiency of the students (Rohaan, Taconis, & Jochems, 2010). Elementary teachers indicated they have limited knowledge, self-rated familiarity, and inadequate confidence to teach engineering, design, and technology (Ganesh, 2010; Knight & Cunningham, 2004). These teachers share the perspective that these disciplines are very narrow relative to the career choices they encourage, such as mechanics, construction workers, or software developers. This causes the students to believe these disciplines are not very applicable to a broad population (Hsu, Purzer, & Cardella, 2011). A teacher’s belief regarding subjects correlates with their teaching practices, which can greatly impact student outcomes (Hsu, Purzer, & Cardella, 2011). This can be a detriment to the students depending on the belief. Some teachers may believe that to participate in engineering courses, a student must be a high achiever; thus low-achieving students may not be encouraged
to take these courses. However, the skills involved in engineering, such as problem solving and critical thinking, are not necessarily virtues of high-achieving students only.

Many teachers find it difficult to make connections in subjects such as social studies with STEM. These socio-scientific connections are imperative in students becoming competent citizens. This type of education can help students in making conclusions about issues regarding society in terms of economics, social, ethical, and political realms. Problems can be provided more contexts for resolution, especially when examining global issues such as energy and resources (Rose & Barton, 2012). Through understanding the past and the role of STEM in the decisions and outcomes that have occurred, future decision makers and leaders can make more informed decisions.

The Next Generation Science Standards is new sets of standards developed by The National Research Council (NRC), the National Science Teachers Association, The American Association for the Advancement of Science, and Achieve in 2011. These standards were created in an effort to develop timely, relevant, and research-based science standards that allowed teachers the necessary flexibility in their classrooms to simulate learning based on students’ interests. Achieve conducted a survey regarding the public’s attitudes about science education in the United States, and 97% of the participants indicated that improving the quality of science education is important for the United States to compete globally. Survey participants stipulated that local and national science education should receive a “C” for its quality (Achieve, 2017). Much advancement has been made to science and technology, and these new science standards are meant to reflect these advancements. Standards were developed for life science, physical science, earth and space science, and engineering for grades K-12. The standards are implemented in a coherent manner that progresses students through the grades with the
knowledge to prepare for the college or a career and are based on internationally recognized assessments (Next Generation Science Standards, 2017).

The Next Generation Science Standards consider three dimensions: Scientific and Engineering practices, Disciplinary Core Ideas, and Crosscutting Concepts. The Scientific and Engineering practices include: asking questions and defining problems, planning and carrying out investigations, analyzing and interpreting data, developing and using models, creating explanations and solutions, having arguments using evidence, using mathematical thinking, acquiring, analyzing, and communicating data. Disciplinary Core Ideas contain the main science concepts of physical, earth and space, life, and engineering, technology, and application science. The Crosscutting Concepts include: patterns, cause and effect, scale, proportion, quantity, systems and systems model, energy and matter, structure and function, and stability and change. These concepts emphasize the connections between analysis and phenomena rather teaching content in isolation. Students are expected to use problem solving, conduct investigations, and discuss open ended questions, which will lead to the construction of knowledge of the content. This will occur via teacher guidance. The new set of standards decreases the amount of direct teaching time for classroom teachers, and states were given a choice for adoption of the standards (Next Generation Science Standards, 2017).

With the Next Generation Science Standards, STEM integration is more prevalent in the implementation of the standards. The standards make the connections to STEM skills and concepts more clear for teachers to follow, which allows more ease in integration. This type of policy change can impact how teachers feel about STEM integration
Need for STEM Readiness

The growth of STEM careers throughout the past decade demonstrates the need for the education system to focus on STEM readiness. It is the responsibility of the education system to prepare students to be productive citizens with career options. Without this focus, employers will have difficulty in filling positions, and graduating students will be incapable of attaining such positions. Thus, employers and educators are dependent on each other.

According to the U.S. Bureau of Labor Statistics (2017), 8.6 million occupations are STEM-related, which comprised 6.2% of the job market. A majority of the STEM jobs are related to computers and technology. STEM jobs receive an above average salary in the United States, with the average for these jobs at $87,570 compared to the average for other non-STEM jobs at $45,700. The highest paid STEM jobs are petroleum and agricultural engineers with an average salary of $150,000.

The availability of STEM jobs grew 10.5% with only a 5.2% growth for non-STEM occupations from 2009 to 2015. This growth means there is a need for additional qualified workers in STEM-related jobs. The mathematical/science group of STEM occupations is projected to be the fastest growing group in the STEM fields with a 28.2% rate of increase between 2014 to 2024. Some companies, however, are outsourcing their employment to workers in other countries because they are more qualified based on their experience and education. Additionally, 99% of STEM careers require a post-secondary degree compared to 36% of all occupations (Vilorio, 2014).

The global future is dependent upon STEM careers because of many environmental challenges that need resolution. These include energy efficiency, environmental and climate changes, limited natural resources, health care and diseases, and technological advancements.
To make an impact or change in these areas of need, future workers need more than an educational background in the subject area to be successful. Future workers also need the necessary skills to solve the issue and see them to fruition. These types of skills are built through experience and practice rather than content (Bybee, 2013).

**Career Interest Development**

As early as kindergarten, students are often asked what they would like to be when they grow up. While this may appear to be a simple question, the goal of education is to prepare each student for jobs they may wish to pursue. Education strives to develop the skills and knowledge necessary for the future. STEM education would endeavor to increase interests in STEM careers. Career choice understanding is valuable in the implementation of a STEM program to attain this goal (Vilorio, 2014).

There are many contributing factors that theorists identify as influences for career interests. These include self-interests, socioeconomic background, occupational image, the luxuries afforded by the career choices, traditional jobs based on gender, prestige levels of the jobs, and familiarity with occupations. Career development starts at an earlier age than many studies identify, often before the age of 16. Before this age, children are exposed to stereotypical images and attitudes that impact their thoughts on prospective careers and work environments (Watson and McMahon 2005).

The Organization for Economic Co-operation and Development (OECD) (2008) found that the image of scientists and technology professions were primary factors in students choosing to become STEM professionals. Many children have an interest in science and technology until the age of 10. However, then students tend to indicate that these types of careers are not meant for them (DeWitt et al. 2013).
The environment impacts a child’s development of career interests in many ways: such as biological or genetics, parenting influences such as parent income and educational level, and culture (Bryant, et al., 2006). Interests, motivations, and beliefs regarding ability have an impact on career choice development (Nye, et al. 2012). Schmitt-Wilson and Welsh (2012) studied students in grades 4-7 and determined that vocational knowledge was a main predictor for career interests and expectations. However, students, teachers, parents, and counselors were not well versed in the opportunities that may increase interests in STEM field opportunities (OECD, 2008). Primary teachers, especially, do not have knowledge regarding STEM career paths due to stereotyping, gender, and lack of training in the STEM fields (Van Aalderen-Smeets et al. 2012). These aspects may lead to students developing a lack of interest in STEM disciplines because of the beliefs of others rather than self-interests and self-efficacy. These students are led to believe that these fields are very challenging.

Career choices and aspirations are life-long developments that change for many reasons and under a variety of circumstances. Young children up to age 10 typically make career choices that are often unrealistic for most of the population; though it is attainable, only a select few become a famous singer or professional athlete (Helwig, 2001). Over half of children ages nine and 10 year olds believe that they have made decisions regarding their future career (Seligman, Weinstock, & Heflin, 1991). However, 23% of adults ages 40-55 stated that their career choice was connected to their choice as a child.

There are a several theories surrounding career choice development. Ginzberg (1952) postulated that children up to age 11 maintain unrealistic views of their future career because it is void of rational and realism. This fantasy period is based on the child’s interests and wants, and it ignores a sense of ability or exclusivity. These roles are often stereotypical, such as teacher,
police officer, or doctor. These careers are displayed in children’s imaginative play, ranging from dress up to acting out the role of the job. Next is the tentative stage which ranges from 11 to 17 years of age. In this stage, children become more realistic about their options. They begin to consider their likes and dislikes, their strengths and weaknesses, their values, and the breadth of career options. Exposure to career choices can be an important role in education during this stage. As students begin to transition in adulthood while become more responsible and self-reliant, they enter the realistic stage. In this final stage of career development, young adults consider career options for college or career opportunities. They must become committed to a job or career for practical purposes. While a choice must be made, young adults have the mindset that their choice is not final and can be changed. Crystallization, which describes a commitment in a career, occurs when the student becomes engrossed in the career and knows it is a suitable choice.

Gottfredson (1981) theorized that children between the ages 3 to 5 begin to understand that adults have jobs, and they too will have a job when they are older; rather than believing they can completely change their being, such as becoming an animal or a fiction character. Between the ages of 6 and 8 years old, children begin relating jobs with concrete aspects, such as clothing or equipment. Gender stereotyping begins at this age in which children view certain jobs as male and female professions. When children are 9 to 13 years of age, they begin thinking about the value and perception of the job. Their choices are based self-perception and what they feel is accessible to them or ‘good enough’ for them. They begin eliminating jobs that are viewed as either above or beneath their own perceived value or abilities. By age 14, children begin evaluating job alternatives and struggle with finding their best fit. They disregard any occupation that does not suit their interests or needs.
There are numerous aspects and facets to career choices and development. Student exposure to careers, specifically STEM careers, has a positive impact on their career choice decisions. When children are exposed to a variety of STEM careers, students were more likely to be more interested and feel more able to pursue a STEM job in the future (Kurz, Yoder, & Ling, 2015). The implications of this study are that students need to be exposed to jobs, particularly in STEM fields, to begin filling the gap the United States has in the STEM professions. Proponents for STEM integration have a focus on STEM career awareness due to the vested interest of its future. Students need to perceive they are capable of STEM careers regardless of gender, perception, and socioeconomic status. With early and frequent exposure, these experiences will guide students to take interest in a STEM related profession.

Teachers need to receive special training regarding career exposure. This should include the identification of any biases and re-creating the stereotypes so that students are not negatively influenced by teachers. Teachers and students should be challenged to question and contest the assumptions about science and technology. Schools need to expose students to a wide variety of STEM careers, opportunities to role play, and foster objective and accurate knowledge about STEM professionals.

**Minority Groups in STEM**

An important role of STEM education is to engage minority students, including African-Americans, women, and economically disadvantaged students (Schultz et al., 2011). This is known as the “STEM Leaky Pipeline” (Griffith, 2010). Racial and ethnic minorities tend to continue at lower rates in STEM fields than their Caucasian counterparts. Minority students leave the field of study by either dropping out altogether or choosing a different path. This negatively impacts the social mobility rates of these groups, which makes it difficult for these groups to become prosperous and improve their circumstances.
Of all STEM positions obtained in the United States, 76% are Caucasian, 17% are Asian, and the remaining 9% are made of other ethnic groups. This is disproportionate to the United State population. Minority groups and women represent nearly 70% of the student population attending college in the United States; however they only make up 45% of the student body seeking a STEM degree. Only 26% of STEM workers are female, which exemplifies the disparity between men and women, although the inequality in wages between men and women ($0.92 to every $1.00) is less than in most other fields ($0.72 to every $1.00), including those in which women are the majority. Women hold 20% of graduate engineering degrees; however only 11% actual pursued an engineering job post-graduation (Tennessee Department of Education, 2017).

Research suggested that the gender gap in STEM field may be due to surreptitious discrimination, bias, career preferences and family/relationship choices. Many women indicated that resources were lacking during times of harassment or discrimination. In a study at Massachusetts Institute of Technology, women encountered smaller work spaces, smaller start-up packages, and larger teaching loads (McCullough, 2011). There is also a lack of female role models and mentors in STEM careers. Without these role models, girls feel less inspired to study STEM career disciplines. Girls who are exposed to female STEM experts are more likely to have a more positive attitude, sense of self-efficacy, and feel connected to STEM options in college (Stout, et al., 2010).

Griffith (2010) stated that the environment of the STEM classroom and work environment fosters attrition due to the ‘chilly’ nature. STEM environments need to be more inviting and nurturing so that students can maintain the interest and stamina to remain in the
program. Kendrick, Nedunuri, and Arment (2013) advocated that a mentoring system is necessary to develop the interests for minorities in STEM disciplines.

**Theoretical Framework**

The Situated Cognition Theory posits that students should be working in such a manner that most closely resembles the context with which it will be applied (Collins, 1988). The apprenticeship model of learning through experience exemplifies this theory. Relevancy to real world is critical for this type of learning. According to Carraher, Carraher, and Schliemann (1985), students are able to understand their learning through the context rather than a stand-alone concept.

There are four benefits to conducting learning through situational cognition. First, students are able to immediately resolve which contents are relevant and valid for the skill. This contrasts the traditional method of explicit instruction with no context, then placing the skill into context through a simulation of the practice. There are similarities to speaking a foreign language; it is better to experience language immersion rather than learn the language in a classroom. Situated learning occurs when student teachers participate in practicums. Foreign language development and teacher practicum opportunities are both examples of authentic experiences conducted so that learning can take place. A simulation is meant as an unauthentic experience that places context, such as contextual math word problems with paper and pencils. Students must also use problem solving and critical thinking skills as they maneuver through the experience, which increases engagement and understanding. Next, implications of the knowledge are immediately presented to the students. They are able to determine what they do not know to be successful in their task, and without this knowledge they will fail. Finally,
students will be able to determine what other connections they can make to this new knowledge or how it may be applicable to other experiences (Collins, 1988).

Lev Vygotsky introduced the idea of apprenticeship learning. He believed that children should learn through authentic tasks that are just above their zone of proximal development. There is a need for a facilitator when tasks are even slightly above the ability of students. The facilitator instructs students in what they need to know to ensure success. This type of scaffolding will allow for the child to develop a sense of understanding of the skills that were intended to be taught. The cognitive apprenticeship approach begins with the teacher taking on the role of the expert. There is a gradual release of independence for the student until mastery is achieved. Students learn to apply strategies through the relevant activities created by the teacher (Oliver, 1999).

Situated cognition is most visible in authentic learning environments. This setting connects what students are learning to real world problems, contexts, and applications. It is interdisciplinary and encourages students to think deeply about topics and question and solve problems. There is a belief that skills and new knowledge does not take on meaning without the student knowing how the information is useful to them. Learning should take place among others to solve problems, collaborate, and share knowledge in real world, relevant activities. Educators often find this method difficult to measure mastery; therefore there is controversy over its use, and it is difficult to measure with a letter or number grade.

There are 10 design elements for authentic learning environments (Lombardi, 2007). The environment should include real world relevance through the use of real world tasks that would be seen in current contexts. The key element is that the scenarios are realistic. The problems should be ill-defined and not easily solved. There are multiple methods and paths to a solution.
Student interpretation prompts critical thinking about the problem. The investigation should be sustained because the problems are ill-defined. This inspires perseverance and student use of multiple resources and perspectives. They must also consider their own perspectives and theoretical lens to determine their path to resolution. Collaboration is a key component to an authentic environment. Students must work with others to solve the problem or issue, and task must be set up in a way that makes this necessary. Tasks should allow for participants to reflect on decisions. Multiple subjects should be entwined in the task from an interdisciplinary perspective, and it should be understood that relevancy is not tied to one subject. Students should recognize that decisions have consequences outside of the subject being explored. Assessments should be integrative because paper and pencil assessments are not conducive to these settings. Evaluation is completed in a manner that resembles the real world and real world professionals. The products of the task are not meant to be exercises, but are valued, whole, and polished. These products could be actual solutions to the problem or issue and should be appreciated as such. Due to the ill-defined problems and diverse interpretations, there are many products for the resolution. This understanding is necessary for the evaluation process and for the students. Students cannot believe there is only one right way or answer. Multiple interpretations are most reflective of the real world context and are necessary experiences for the students.

There are similar connections to STEM integration which allow for guidelines to be rendered from these design elements as a conceptual framework for STEM education. Both concepts are meant to construct knowledge through authentic tasks with real world contexts. This type of framework can be accomplished if teachers trust their students and allow them to have authority over tasks and learning with the help of a mentor (Ayar & Yalvac, 2010). STEM
education’s goal is for students to develop skills and knowledge through interdisciplinary issues, which is the basis for situational cognition (Sahin, Ayar, & Adiguzel, 2014).

**STEM Practices and Standards**

The practices for STEM integration are highly influenced by the definitions of those who develop the program or model. However, for them to be considered practices, they must be used consistently and at the core of instruction (Bybee, 2013). The practices must reflect the vision for STEM integration that were agreed upon by the members of the school. Brown, Brown, Bearden, and Merrill (2011) conducted a study to determine the understanding of STEM among teachers and their principals. The findings determined that over half of the principals did not have an understanding of STEM education, including those with teachers in STEM-focused graduate programs. Thus, there was not a clear vision of STEM education.

There are many definitions of STEM integration that have been created and adjusted depending on the organizations’ needs or perceptions at the time, which impacts the practices being implemented. STEM integration is used to describe classrooms, schools, summer programs, advertisements, jobs, etc. Some definitions reference all four disciplines, science, technology, engineering and math; however there is an emphasis placed on only one of those subjects, such as a math class. Other definitions weight each discipline with the same importance with time and energy; however they are taught in isolation. Others define it as the integration of all four disciplines. The definition of STEM is important to the development of any STEM program or model because the definition influences its foundation. STEM viewpoints are influenced by the individual’s field of work, place of work, and background (Bybee, 2013).

As STEM continues to develop across the nation, the term and its many definitions are being assessed to distinguish schools with exemplary programs. However, STEM is unique to
the classroom, school, grade level, or subject being taught. The numerous definitions of STEM influences each of the assessments used to evaluate a school. Organizations such as AdvancED and the Tennessee STEM Initiative Network have created pathways for STEM certification. Some states have created their own STEM certification process, including Tennessee, Georgia, Texas, Indiana, North Carolina, and Ohio. Tennessee is the most recent to create their own STEM certification (Tennessee STEM Initiative Network, 2017). The certification processes provide the certified schools a level of stature and acknowledgement for their efforts, which can send a positive message to all stakeholders. The certification processes for many organizations are based on a created rubric and include data gathering, observations, and interviews. These rubrics do not mandate that a specific model of integration to be used; however it examines the depth of certain key STEM ideas. The schools must attain a certain depth for each of the STEM ideas to become STEM-certified. The examination of the variety of STEM rubrics can offer insight into STEM ideas and practices that can be utilized when creating a STEM-integrated program or model.

The Tennessee STEM Initiative Network (TSIN) (2017) in conjunction with the Tennessee Department of Education (TDOE) (n.d.) created a STEM certification process that endorses schools as official Tennessee STEM schools if they meet the criteria. The schools which meet these standards become Tennessee model schools, and others schools may visit to gain insight into STEM practices. Certification is based on a set of priorities, which were developed by a STEM Leadership Council organized by the TDOE. These priorities include: infrastructure, curriculum and instruction, professional development, achievement, and community and post-secondary partnerships. STEM schools are evaluated based on the continuum of early, developing, on target, or accomplished rankings. The TDOE also decided to
make connections across the math and science standards during their recent standards revision process so that educators can integrate STEM learning in more meaningful ways and promote STEM thinking among the students.

According to the Tennessee STEM Initiative Network (2017), there are five priorities of infrastructure, curriculum and instruction, achievement, professional development, and post-secondary partnerships are outlined with specific expectations. Infrastructure includes the leadership teams, plans, and professional development schedules that are being utilized to integrate STEM effectively. The curriculum and instruction priority, as it relates to elementary school settings, highlights the math and science standards that are currently connected by the TDOE through the revised standards. The curriculum and instruction priority will occur through the use of STEM vocabulary and practices, integrative activities and lessons, including all content areas, explicit discussion of STEM careers, and professional development related to STEM integration for math teachers, science teachers, instructional coaches, and guidance counselors. This priority also emphasizes the use of project-based and problem-based learning.

To promote the achievement priority, the STEM certification organizations expect rubrics to be implemented by the schools that assess academic performance and STEM skills. It is also expected that data are used regularly to make educational decisions. STEM professional development is expected to be ongoing and relevant so teachers are able to create STEM experiences for students. The component of post-secondary partnerships is used for real world relevancy and practical applications of content. It is meant to create student awareness of STEM professions and increase readiness after high school.

STEM standards and expectations are also established at national and international levels via organizations and accrediting agencies such as AdvancED. The examination and comparison
of these rubrics can also influence decisions throughout the creation or integration of STEM models or programs. AdvancED’s (AdvancED, n.d.) certification encourages the awareness of STEM education and its benefits, increased expectations for teachers and students, and a commitment to high quality STEM education. The AdvancED rubric consists of only three priorities: STEM learners, STEM educators, and STEM experiences. The focus on the learners, or the students, includes nontraditional students, such as girls and African Americans, in STEM fields. Schools must determine how these minority groups will be engaged in the STEM learning through interests. The learning environment should focus upon real world problem solving. The learning should be driven by student interests and assessed through performance based assessments. Students are also expected to utilize technology for the purposes of learning and collaboration on a regular basis. Teachers are required to create a problem-based curriculum through collaboration with their peers. They are to teach STEM skills through demonstration and facilitation. Teachers are also required to participate in continuous professional development. STEM experiences are also an expectation of the AdvancED rubric. Students should be offered STEM opportunities outside of the school day to include time spent with community and business leaders in real world contexts.

The Tennessee Department of Education (2017) and AdvancED (n.d.) share similarities in their expectations and standards for schools proposing to be a STEM school. These similarities include a focus on continuous teacher professional development, teacher collaboration, student participation in real world problem-based learning, and utilizing the community and post-secondary opportunities to expand student’s knowledge and interests in STEM careers. Some differences were observed as well. The focus of each component was stressed in different ways depending on the organization. AdvancED does not address the use of
STEM skills in students; whereas the TDOE consistently mentions STEM skills and their importance. However, the TDOE does not address the issue of students that are underrepresented in STEM fields. The acknowledgement of these similarities and differences demonstrate the differences in models that can be observed among schools with an emphasis in STEM integration. Some of these components can be utilized in the determination of factors that are important to STEM integration when seeking to implement STEM in a school setting.

**STEM Culture, Instruction, and Assessment**

School culture encompasses the beliefs, ideas, and practices of all stakeholders involved. It is a culmination of the written and unwritten rules that are often transferred to each person that becomes a part of the school. Schools function as a result of their cultures (Glossary of Education Reform, 2013). Culture is related to the belief systems of the school, but it has been formed through the continuing practices and ideas of those involved. To remain a part of the collective group, teachers often conform to methods in place within a school (Gruenert, 2008).

STEM integration becomes a part of the school’s culture because the philosophy of STEM integration impacts the beliefs, perspectives, and ideas of a school. There should be an establishment of shared beliefs, practices, and models in support of STEM integration. The outcomes of integration are influenced by the school’s culture. Conversely, the school’s culture is influenced by integration. Student focus and outcomes are key elements in identifying a STEM-integrated school (National Research Council, 2011). Teachers and administrators should expect that students are being prepared for real world professions rather than an end of course tests. Real world experiences, especially in mathematics, enhance student achievement rather (Stone, Alfeld, & Pearson, 2008). The skills developed in context are not necessarily the skills being enhanced in test preparation-type settings. Ideas such as motivation, creativity, and
interest should be a concern for the staff. These ideas are facilitated and expressed through the
culture of the school. The outcome should result in students becoming interested in STEM
careers; thus expectations should be high through encouragement that students, especially
minority students in STEM, participate in STEM courses in middle schools and high schools.
These school cultures should foster an expectation of encouraging student interests and not
solely teaching to the tests (National Research Council, 2011). STEM schools need to have a
supportive culture in which the faculty and students feel safe to experiment with new ideas.
STEM integration is meant to resolve real world issues. Many problems do not have a specific
answer; therefore there is a need for trial and error. The faculty and staff should feel at ease
asking for assistance when needed. Due to the nature of STEM, collaboration is essential to its
success, so there should be an expectation that all stakeholders should ask for help when needed.
This can be emphasized in the norms that are created by leadership (Chiu, Price, & Ovrahim,
2015).

The school’s vision and mission provides insight into the shared culture and belief
system. It gives the stakeholders guidance for their focus, expectations, and practices. Mission
statements have a significant impact on the school’s STEM culture. There is a clear connection
between expectations stated in the mission statement to the expectations emphasized by the
stakeholders as a part of their culture. This influences the STEM integrative programs and
practices being offered to their students (Scott, 2012).

The United States Department of Education (2015) issued a statement regarding its vision
for STEM education. The goal of STEM education is to motivate action among communities to
build solid evidence for STEM teaching and learning rather than prescribing a program to be
followed for STEM integration. There are six main components that highlight the challenges
and opportunities for the practice of STEM integration. These include: creating an engaged network STEM community, activities that are designed for intentional play and risk, interdisciplinary approaches as culminating tasks, flexible and comprehensive learning spaces, performance based assessments, and the promotion of diversity in STEM learning and careers. It is believed these opportunities should start in preschool and be available to all learners. A solid foundational STEM education is imperative to fill the racial, cultural, socioeconomic, and gender gaps that are prominent in the STEM disciplines.

**STEM Professional Development**

For effective STEM instruction to occur in schools, teachers need adequate and effective professional development. If teachers are effective in STEM instruction and integration, especially at the elementary level, students will become more interested in the STEM disciplines throughout the remainder of their academic careers. This STEM pipeline is necessary for the future development of STEM professionals. Students are often dependent on their teachers to provide them with this exposure and these opportunities to make career decisions, especially in the STEM fields (National Research Council, 2011).

STEM professional development can range from brief meetings led by other teachers to universities providing ongoing training. This training focuses on systems thinking and the broad perspective that relates to STEM disciplines through inquiry-based instruction. This is different from the typical teacher training because teachers typically understand the instructional methods necessary for their respective courses (National Research Council, 2000). When teachers are provided training regarding models of STEM integration, they are more likely to modify their teaching (Levitt, 2001).
Elementary teachers need inquiry-based instruction professional development. Teacher confidences level is the main predictor of the outcome for integration. Teachers with negative attitudes towards STEM typically avoid teaching STEM. Although engineering is the STEM component that connects all other disciplines, teachers are most often less confident in this area (Nadelson, et al., 2012).

Custer, Daugherty, Zeng, Westrick, and Merrill (2007) noted that several dimensions need to be considered to be effective when creating professional development opportunities for STEM integration. These include: development of a vision, standards-based curriculum materials, interdisciplinary STEM subjects, research in STEM integration and instruction, and justification for engineering and technology content. These aspects are important for teachers to gain understanding of their expectations and how STEM integration is relevant to them in their classroom.

Avery and Reeve (2013) contended that there are six recommendations when conducting professional development that would facilitate teacher integration of STEM instruction. Teachers should have sense of ownership in the training through the support of their ideas. This ownership will lead to more buy-in and success of the program. Teachers also need to witness examples of STEM instruction and participate in STEM instruction. This can occur through actual participation, videos, and stories that serve as exemplar lessons. Teachers require training on the management of group projects. Group work often means that less content is covered; thus teachers need to know how to make the most of their time. Necessary standards must be discussed during development so that teachers can make important connections between state standards and STEM integration practices. Professional development should include training teachers on creating their own STEM lessons. Teachers need to be aware the resources available
to them so that integration does not stop due to the lack of materials or creativity. Teachers also need to know how to use the materials they already have to integrate STEM.

**Strides in STEM**

Schools are striving to meet the demand of a growing technical workforce. Schools are utilizing the situated cognition theory of learning through the implementation of problem-based learning and project-based learning (Torp & Sage, n.d.) This theory posits that the development of any skill is best learned through context, rather than in isolation, which occurs in many elementary schools in the United States (Browns, Collins, & Duguid, 1989). Problem-based learning and project-based learning have become strategy for adapting to the shift from isolation to collaboration and skills-based teaching and learning (Miller, 2014). Purposeful integration of STEM subjects increases retention, encourages higher order thinking, and enacts problem solving, which is the goal of problem-based learning and project-based learning, as well STEM integration (Stohlmann et al., 2012). Common Core Standards, Next Generation Science Standards, and technology standards that have been passed at both the national and state levels are additional strides in STEM development. They each encourage the integrative ideas of STEM and the skills that are sought for post-secondary experiences (Bybee, 2013).

The focus of schools should be on the STEM processes as opposed to teaching the necessary content in order to prepare students for real world science experiences (Roth & Eijck, 2010). This type of learning promotes science as a problem/solution, critical thinking, and open-ended inquiry-based process as opposed to teaching specific content (Wood, 2008). A strong correlation exists between students taking advanced science and math courses in high school and their graduation rate in college. This correlation implies that early exposure to STEM education
will perpetuate and motivate future success in college due to an increased interest in science and math (National Science Board, 2010).

The Partnership for 21st Century Skills (2004) initiative strives to develop the skills necessary for the incoming workforce through partnerships with educators, policy makers, and community members. The program’s aim is to develop the skills of collaboration, problem solving and critical thinking, communication, and creativity into the areas of reading, writing, and math. Success has been modeled when engineers and other STEM professionals have been utilized in the development of STEM activities. Student exposure to STEM careers is a driving force behind STEM interests and motivations (Swift and Watkins, 2004). The Partnership for 21st Century Skills’ (2004) goal is to create equality among all schools in these capacities across the country. The hope is that early exposure to science, math, and technology-integrated will foster a continued student interest in STEM careers in order to fill the growing trend of the field.

While STEM initiatives are being implemented across the across the country, much of their focus remains on the middle school and high school levels, rather than the elementary school level (Vasquez, 2005). Elementary STEM programs are beginning to form as teacher preparation programs are acclimating to meet the need for STEM teachers. The focus of elementary schools is linking the existing curriculum with STEM skills for inclusion in science, technology, engineering, and math. However, due to the necessity of foundational skill work in reading and math, this is often problematic due to time constraints.

Effective STEM instruction should include a variety of criterion to be successful. Students in a successful STEM-integrated classroom should be problem solvers, innovators, inventors, and logical thinkers. The classroom environment should prompt the development of skills of self-reliance and technological literacy. Most STEM educators agree that integration
needs to focus heavily on problem solving and solution development, as well as inquiry-based learning (Morrison, 2006). Educators should have early and repeated exposure to integrated STEM subjects and skills (National Research Council, 2011). This type of learning is novel to the elementary setting as it requires a greater amount of autonomy for the students and the level of scaffolding can be difficult to gauge.

**Immersion Levels**

There are five different levels of integration utilized at all levels of education for STEM implementation: full immersion, partial immersion, and minimal immersion, as well as exploratory and introductory phases. Full immersion is the immersion of the whole school or district STEM implementation. The classroom environment is established as a work environment as opposed to a traditional setting. Students work together to solve community issues or problems. STEM skills are the driving force of the instruction and curriculum. There is integration of all subjects as the students work in a problem-based setting. Teachers work as facilitators of learning in conjunction with business partnerships. The teachers partner with each other across grade levels and subjects to create the experiences and projects. The students also participate in job shadows and internships to add to their experiences. This type of immersion is typically displayed only in the high school setting (United States Department of Education, n.d.).

Partial immersion includes the STEM skills and experiences for integration into the instruction. However, this is in addition to the regular curriculum. Partial immersion does not constitute school wide integration. Certain classes or groups could be integrated while the others are not. The school or classes may choose to only participate in long-term STEM projects. This type of immersion is a stepping stone to full immersion. Minimal immersion entails a traditional education environment. STEM integration and problem/project based learning is used only as a
supplement to the existing curriculum. The projects involved are short-term throughout the year. Students are minimally exposed to STEM skills in preparation for career readiness (United States Department of Education, n.d.; Science Foundation Arizona, 2016).

The introductory phase may be utilized after state testing has concluded. This may include stand-alone units that are not integrated into the regular curriculum. Finally, the exploratory phase is a traditional classroom environment with a regular curriculum; however there are extracurricular activities that are STEM-related such as clubs, summer programs, and robotics. The goal of this phase is to explore a new idea (Science Foundation Arizona, 2016). This hierarchy of immersion can be utilized to direct a vision for STEM integration for any school planning to implement.

Implementation Challenges

As many initiatives compete for the attention of funding and focus of schools, STEM education is no different. The educational landscape is constantly changing, which causes difficult decisions to be made. The decisions can be based on politics, money, or immediate needs. Rincon and Jackson (2016) conducted a study to determine the funding practices of STEM programs across the United States. They revealed that regardless of the national need for STEM education, STEM funding was most often cut for the purposes of other initiatives. Funding cuts can be detrimental to student STEM experiences, teacher professional development, and necessary supplies for schools that wish to have a sustainable STEM program.

Standardized testing presents challenge for STEM integration. While standardized testing is meant to evaluate the content knowledge of core subjects such as math, language arts, and science, these tests take away from instructional time. Schools and teachers feel the pressure of accountability, especially for mathematics and language arts test scores. On average,
elementary schools spend 323 minutes per week on math instruction but only half as much time for science. Districts report an emphasis on decreasing this time to only 75 minutes or less (National Research Council, 2011). The narrowing of the curriculum due to the pressure of standardized testing and accountability has limited teachers’ ability to integrate and teach the addition of STEM skills (National Education Foundation, 2017). A more holistic assessment is warranted to evaluate content consistent in a STEM-integrated classroom. The assessments need to be more individualized and performance-based such as the utilization of portfolios, so that STEM skills and real-world contexts can be observed and assessed. STEM content is not linear in progression, so typical standardized assessment cannot be used.

Likewise, mandates such as Response to Intervention, special education, and physical activity requirements, now require allotted amounts of daily instruction that must be uninterrupted. This presents a challenge for teachers as there are instructional restrictions during this time. These efforts are, in part, to raise scores on standardized tests (Response to Intervention Action Network, 2017).

Teacher training is another challenge associate with STEM implementation. While teachers at any level may be expected to integrate STEM into their classroom and curriculum, their teacher preparation program may or may not have been developed in a manner to do so. Preparation should include technology integration, engineering design, and problem-based learning. Likewise, veteran teachers are in need of ongoing STEM professional development because many of these veteran teachers lack the confidence to integrate. They need assistance in methods to amend their current curriculum to meet the expectations for STEM integration of the school or STEM certification organization (Bencze, 2010). Teachers need to develop a sense of self-efficacy to be comfortable and confident in integration. The more confident these teachers
feel, the more likely they will be to integrate regularly (Ross, 1998). Self-efficacy is underutilized since many elementary teachers have not had experience with upper level math or sciences to be able to understand the dynamics of using each. High schools are now able to hire STEM professionals as teachers for particular classes, which allows for alternative perspectives from those that have worked in actual STEM professions. However, the responsibilities of an elementary teacher are vastly different from those of a high school teacher. The experience of a STEM professional as a teacher can reveal information regarding the workforce, so elementary teachers need this exposure through externships and job shadow opportunities (Epstein & Miller, 2011). STEM teacher leaders would be an additional asset to a STEM program because they could provide STEM professional development, conduct model lessons, and meet with peers to discuss planning. This is an additional need in schools choosing to integrate STEM (Office of Innovation and Improvement, n.d.).

Students of all ages that require different types of accommodations due to disabilities will need additional supports to participate and benefit from a STEM-integrated classroom, such as the use of lab equipment. These accommodations may be through the use of technology platforms. Students in rural areas, living in poverty, and English Language Learners may also need additional support because they may not have access to necessary technology. Many teachers need to debunk the stereotype that only those students gifted in engineering and technology need to pursue a STEM career. This premise is based on teacher’s own experiences and stereotypes of the career field. These are skills that can be developed in all students rather than only those with a natural talent or early exposure technology and engineer design. This type of thinking stifles innovative teaching that could be helpful to all students. Teachers also need to reconsider the hierarchy of disciplines. It is typically believed that math is the top priority in
STEM, followed by science, then by technology and engineering. However, an interdisciplinary approach should be instituted as each of these concepts is integrated with one another. They are not meant to be taught in isolation of each other (Partnership for 21st Century, 2004).

Funding for STEM education is another challenging component. This type of funding is not built into the annual budget from any funding entity; thus it must be met through business partnerships and grants. The Every Student Succeeds Act, which describes a STEM focus, offers some funding; however it is flat funding model and does not increase with need (American Institute of Physics, 2016). Many schools still lack the technology necessary to teach students the foundations of computers due to a lack of funding, yet computers are a vital component to instruction with standards and assessment. Technology and engineering are the two most difficult components of STEM education to be used in schools due to resources and understanding (Bybee, 2013). This pitfall in funding creates a gap in the students’ abilities in the future as they are expected to utilize or even create new technology.

The success of a STEM school is a somewhat vague component because it is not easily measured in the short term. It can be difficult to determine if the success of the program is attributed to the type of instruction and culture of the school or merely the population of the students who attend. Success can also be determined in many ways, such as science and math test scores or the number of students enrolled in college STEM courses and majors. Each school must define its own success, and the path to achieving this success (National Research Council, 2011). These different paths lead to the research of identifying the models that are utilized in elementary STEM schools settings as they have been defined. The definition of these models will allow for schools to be more cognizant of their goal for success and their path for achieving it.
CHAPTER 3: METHODOLOGY

Description of Qualitative Research

Qualitative research was used for this study, specifically a phenomenological, descriptive inquiry so that the many components and the unique qualities of each school could be captured. The purpose of this study was to describe the experiences of the teachers and administrators in STEM schools as a way to inductively conclude the models used. The goal is to describe the defining characteristics of the STEM model being implemented. These descriptions of STEM implementation models can then serve as guidelines to be used as other schools develop and implement STEM programs. Phenomenological research helps to gather data in an authentic manner, which is valuable to this study. Phenomenological research also captures the meanings behind the participants’ actions and words that other research methods could not. This research method allows for adjustments to ideas and theories as themes emerge, which is crucial to the development of the STEM models that were determined from this study.

Description of the Specific Research Approach

For this study, a variety of evidence was collected from many sources to describe the various methods of STEM integration at different schools. Questionnaires, interviews, and artifacts were used throughout this study for evidence collection. Participants took part in a four point Likert scale questionnaire which allowed the researcher to acquire initial information regarding the immersion level of the school and basic information about the school’s STEM assessment, instruction, and culture. Interviews were conducted with the participants in a focus group setting where more in-depth questions about assessment, instruction, and culture were asked.

Artifacts such as fliers for events or team meeting notes were gathered. Research
participants believed these artifacts reflected STEM integration for their schools. Thematic coding occurred for the data collected from the focus groups and artifacts. The four point Likert scale was analyzed by determining a composite score. The coding data led to the identification of the STEM models utilized in the participating schools based on the prevalence of the practice in instruction, assessment, and culture.

**Description of the Study Participants and Setting**

Elementary schools who claim to have a STEM focus as indicated by their vision and mission were included in this study from the East Tennessee region as a convenience sample. The participants in the study were elementary school teachers and administrators. Schools which claim to be STEM-integrated often use their own interpretation of integration. The immersion levels vary in each of these schools; thus their models will be varied. This study sought to identify these models.

**Data Collection Procedures**

Teachers and administrators from the identified STEM schools were provided an initial Likert scale questionnaire with questions regarding their assessment, instruction, and cultural practices. A composite score from the questionnaire was calculated for each of the topics for the individual schools. The composite scores were compared across topics to determine differences and similarities among the schools, which was used in the coding method after all data collection was completed.

Each school participated in a focus group interview in which in-depth questions were asked regarding STEM practices in instruction, assessment, and culture. A semi-structured interview was conducted to determine the components and specific model that was utilized. Each participant was asked the same questions. However, follow up questions were posed at the
researcher’s discretion. The interviews were recorded for eventual transcription and coding.

Artifacts such as the school’s website, Facebook page, parent information flyers, meeting notes, and teacher-created materials were also considered in the determination of components to understand the extent to which each of these concepts is emphasized. Research participants believed these artifacts reflected their mission of STEM integration.

**Ethical Considerations**

Participant names and addresses were not provided in the study, and the schools were assigned pseudonyms as their identifier. Accuracy of the information collected was verified by each participant to ensure completeness through member checks. The researcher provided a summarization of the ideas presented throughout the interview to confirm the accuracy of the information. Detailed accounts of the information provided were given so that readers of the research can determine its usefulness in a variety of settings. Additionally, the researcher’s background and personal definition of STEM integration were considered during the evaluation of the data to disable any researcher bias in its analysis.

**Data Analysis Procedures**

The Likert-scale questionnaires were analyzed for similarities and differences by totaling the sums of each category. Schools were placed in certain categories based on their score range. The categories included the immersion levels of full, partial, minimal, exploratory, and introductory. Each school participated in follow up interviews to identify the in-depth components of their STEM program so that a STEM model can be derived. The analysis of the interviews utilized a coding method in which the information from the teachers was categorized based on the most salient thoughts, actions, practices, and artifacts. However, the elements were distilled for relevancy.
Open coding was utilized as the initial evaluation of the data. This was based on the conceptual framework of assessment, instruction, and culture. During this process, codes were revised, removed, and added to accommodate all of the information provided. In this reduction, process or condensing of the information, each code was then examined for patterns through an axial coding process. Such patterns included authentic experiences, real world connections, and problem solving. Due to the phenomenological nature of this study, all of the categories were not prescribed until a theme was determined. In a third level of coding, the data was then evaluated to determine which category held the most prevalence for each type of immersion level. All coding occurred after all data collection occurred.

The semi-structured interviews were analyzed in the same manner. The recorded interviews were transcribed and coded based on the previously mentioned categories. The categories were evaluated for prevalence to determine the significance the participants provided for each category, which helped to determine a model for STEM integration for each particular setting. Member checks were conducted during the interviews to ensure that the participants and the researcher had a similar understanding of the portrayed message. Artifacts such as parent flyers and events, materials, and assessments were also coded based on the most salient thoughts, actions, practices, and artifacts. These artifacts were also helpful in the triangulation of the data to ensure reliability.

**Summary**

The data analysis for this phenomenological study was primarily dependent on researcher coding of the following data due to the nature of the data collection types: interview, questionnaires, and evidence. The coding system is necessary to determine the components that influence each participant’s STEM model so that generalizations can be made about each of
these components. Ethical considerations were effected to ensure that the data gathered from the participants were respected and true, which added to the reliability of the study.
CHAPTER 4: PRESENTATION OF FINDINGS

The focus of this study was to identify STEM integration models for elementary school settings. The data collected during this study provides insight into the ways elementary schools are integrating STEM into their instruction, assessments, and culture of the school. A small amount of research has been conducted regarding elementary schools, so this research is aimed at filling the gaps in the existing research. The study involved collecting data via questionnaires, focus group interviews, and artifacts. The questionnaires allowed for a comparison among the school regarding the depth of STEM integration across the school. The focus group interviews allow participants an opportunity to provide explanatory information about the ways the school integrates STEM. The artifacts included items such as lesson plans, grants, and agendas that gave insight into each schools’ STEM integration. Three schools with interests and emphasis in STEM integration were chosen to participate.

Description of Participants

Data for this study were collected using a convenience sampling of teachers dispersed among three different elementary schools within the same Southeastern Tennessee school district. The schools were chosen based on their mission statements and current STEM integration efforts. School A expressed an interest in STEM through its mission statement, which reads, “To build the foundation for 21st century learners by equipping students to excel in all areas with a focus on science, technology, engineering, and mathematics (STEM)”. School A was originally constructed in 2010 with a STEM lab and STEM as a focus for the school, per the direction of the superintendent. School A currently has 450 students and 23 teachers. The STEM lab is now being utilized as the school’s computer lab due to overcrowding. It has a computer lab equipped for one class at a time as well as 4 laptop carts (30 laptops per cart) to be
shared among the classes, an IPad cart (24 IPads) used for special education students, and one classroom which utilized one IPad for each student. The school has received a variety of STEM grants from local corporations that were utilized to purchase STEM materials. School A has a STEM leadership team that has been in existence for three years. The team is led by a teacher who serves as the STEM coordinator. The team discusses how to incorporate STEM into the school setting. Three of the participants have participated in a regional STEM fellowship, where they gained knowledge about integration. There were five female participants for the focus groups, and all were classroom teachers. Their teaching experience ranged from 3-20 years in grades 1-5. School B references the use of technology and creating an environment that fosters college and career readiness in its mission statement. Many references were made to STEM integration as reason for the school’s appropriateness to the current research. These two components are indicative of a STEM-integrated environment that was appropriate for this study. School B was built in 2002 without a specific emphasis, with a current student enrollment of 650 students and a staff comprised of 28 teachers. School B has a computer lab equipped for one class at a time, as well as one computer cart (30 laptops) and two IPad carts (30 IPads each) to be shared among the school. The school is currently developing a plan for STEM implementation with a STEM leadership team. This focus group consisted of five participants (four male and one female), who taught grades K-5. School C stated an interest in the development of a STEAM lab that was received through a STEM grant. Their endeavor has prompted an interest and promotion of STEM integration. School C was built as a high school in 1911. It has 310 students and 15 teachers. School C recently received a grant for a STEAM lab (Science, Technology, Engineering, Arts, and Math) from a local corporation. School C has a computer lab equipped for one class at a time, as well as a laptop cart (30 laptops) to be used school-wide.
One teacher has participated in a regional STEM fellowship. The staff has received professional development in coding and various other STEM activities. The three participants for this focus group were a librarian, 5th grade teacher, and 2nd grade teacher. All were female with over 15 years of teaching experience. Figure 4.1 identifies the demographics for the participants of the study.

**Figure 4.1**

*Demographics of Focus Group Participants*

<table>
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<tr>
<th>School Identifier</th>
<th>Number of Teachers within Group</th>
<th>Grade Level(s)</th>
<th>Subject Represented</th>
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<tbody>
<tr>
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<td>2nd-5th</td>
<td>all</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>K-4th</td>
<td>all</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>2nd, 3rd, 5th</td>
<td>all, library</td>
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</tbody>
</table>

**Research Question**

What models for instruction, assessment, and culture are elementary schools utilizing to implement STEM integration?

**Data Collection Process**

A questionnaire was distributed to each school via an online Google document. The teachers chose to voluntarily participate with the understanding that the information was anonymous. A total of 32 teachers participated in the online questionnaire, with 10 from School A, 14 from School B, and eight from School C. The purpose of the questionnaire was to identify the depth of STEM integration for each school so that a comparison could be made when
identifying the STEM models for each school, which could further any conclusions with supporting data.

Within these three schools, focus groups were constructed of a group of three to six teachers, chosen by the principal, due to their interests in STEM and school awareness. The focus groups were constructed of classroom teachers from grades k-5, as well as a librarian. Each group of teachers was asked the same in-depth, open ended questions, and their responses were audio-recorded for data collection regarding the school’s STEM culture, instruction, and assessment. Specific questions were aligned to each of these components. The focus group data were used to answer the study’s research question: What models for instruction, assessment, and culture are elementary schools utilizing to implement STEM integration?

Artifacts were also collected from each school that illustrated ongoing STEM integration. Artifacts include meeting agendas, grants, lesson plans, and flyers. These artifacts were used as corroborating evidence in the triangulation process with the questionnaire and focus group data. Artifacts were also used as supporting evidence for the theory framework of each of the models described for STEM integration. The artifacts provided gave evidence for the STEM culture of the school.

**Description of STEM Questionnaire**

To determine the depth of STEM integration within each school, data was collected through an online questionnaire that was sent to the participating schools. The questionnaire was a Likert scale type survey in which each teacher answered a variety questions using the responses: Never, seldom, sometimes, and often (Appendix A). Each of these responses were followed by a time frame such as “once per semester” or “daily,” which allowed the participants
to have a similar understanding of each possible response so that they could be as objective as possible in their answers.

All teachers at each school received the survey; however, not all chose to participate. Each school’s data was collected individually so the data could be analyzed in isolation before being compared to the other schools.

The questions included:

1. How often are STEM professionals invited to work with students?
2. How often do students participate in real world projects or activities?
3. How often do you receive professional development regarding STEM integration?
4. How often are careers discussed during instruction?
5. How often do you integrate technology as part of your instruction?
6. How often is STEM a part of extracurricular activities?
7. How often do students utilize 21st Century workforce readiness skills? (Problem solving, critical thinking, collaboration, perseverance, etc.)
8. How often do students engage in problem-based learning?
9. How often do you discuss STEM integration in lesson planning?
10. Which school are you a part of and what is your role?

**STEM Questionnaire Findings**

Once the data was collected, a value was assigned to each of the responses: Never-0, Seldom-1, Sometimes-2, and Often-3. The highest response each questionnaire could provide was 27, meaning the participant responded with “Often” for every question. The value allowed for a calculation of the average response for each school so that the depth of STEM integration could be calculated and compared. Figure 4.2 shows the data collected from each school.
Figure 4.2

Questionnaire Data

0-Never 1-Seldom 2-Sometime 3-Often

School A

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<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>M</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>N</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>O</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>P</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>.57</strong></td>
<td><strong>1.57</strong></td>
<td><strong>.35</strong></td>
<td><strong>1.92</strong></td>
<td><strong>2.92</strong></td>
<td><strong>1.57</strong></td>
<td><strong>2.35</strong></td>
<td><strong>2.0</strong></td>
<td><strong>1.07</strong></td>
</tr>
</tbody>
</table>
In translating the data to a numeric value, Question 1, from Figure 4.1, received an average score of 1.9, which was rounded up to a 2 value. A 2 value indicates that on average across the school, STEM professionals are sometimes (1-3 times per semester) invited to work with students. The average for question 2 (integration of real-world projects and problems) was a 2.5. This average was rounded up to a 3 value, which indicates that real world projects and problems occur often (four or more time per semester) in School A. Any average that received a half value or above was rounded up to the next value. Averages that contained below a half value were rounded down for consistency.

After calculating the average for each school’s responses, School A was determined to have the most integration occurring, with the average participant survey response of 19.4 of a possible 27. School B had the least amount of STEM integration occurring, with 12.5 as the average participant response. School C was in the middle of the two with 16.75. Figure 4.3 displays the average depth of STEM integration based on the participants’ responses for each
school for each question on the questionnaire. For example, question 1 regarded the frequency
to which STEM professionals were invited to work with students. The highest possible response
was a 3; thus questions closer to 3 were aspects integrated more frequently than those that were
lower.

Figure 4.3

*Average Depth of STEM Integration*

<table>
<thead>
<tr>
<th></th>
<th>School A</th>
<th>School B</th>
<th>School C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Average</td>
<td>19.4</td>
<td>12.5</td>
<td>16.75</td>
</tr>
<tr>
<td>Question 1</td>
<td>1.9</td>
<td>.57</td>
<td>1.5</td>
</tr>
<tr>
<td>Question 2</td>
<td>2.5</td>
<td>1.57</td>
<td>1.75</td>
</tr>
<tr>
<td>Question 3</td>
<td>1.8</td>
<td>.35</td>
<td>1.5</td>
</tr>
<tr>
<td>Question 4</td>
<td>1.9</td>
<td>1.92</td>
<td>2.0</td>
</tr>
<tr>
<td>Question 5</td>
<td>2.2</td>
<td>2.92</td>
<td>2.0</td>
</tr>
<tr>
<td>Question 6</td>
<td>2.0</td>
<td>1.57</td>
<td>1.38</td>
</tr>
<tr>
<td>Question 7</td>
<td>2.5</td>
<td>2.35</td>
<td>3.0</td>
</tr>
<tr>
<td>Question 8</td>
<td>2.1</td>
<td>2.0</td>
<td>2.25</td>
</tr>
<tr>
<td>Question 9</td>
<td>2.5</td>
<td>1.07</td>
<td>1.75</td>
</tr>
</tbody>
</table>

The averages for each question prompted interesting findings used for further discussion.

Question 3 received the lowest average score across the three schools with an average of 1.22,
which addresses the amount of professional development. Question 7 had the highest average
score with a 2.62, which examines how often students utilize 21st Century workforce skills.

School A was higher in all questions except for questions 4 (career discussion during instruction)
and 5 (use of technology during instruction). School B was lower on all areas except for question 5, which was the highest at 2.92. This question refers to technology use during instruction. These values provide insight into the perceived integration for the components examined in this study.

Focus Group Interviews

A focus group was conducted for each of the schools to identify the STEM models utilized by each school. The principal from each school selected the group of teachers to participate in the focus group based on their knowledge and interest in STEM integration. The teachers were asked to consider their school holistically, as well as their individual classrooms when responding to questions. All teachers were asked the same questions in a semi-structured interview. Member checks were conducted to ensure correct understanding of the responses were determined through follow-up questions and restatement of participants’ thoughts. Sessions were recorded, then transcribed all responses for each school. The questions were grouped to include STEM integration in the school’s culture, instruction, and assessments. The questions for the focus groups included:
1. What are the main components of your STEM integration?

2. How do you incorporate STEM professionals?

3. What types of professional development have you received regarding STEM integration?

4. Who are the major contributors of STEM at your school?

5. How does planning for STEM occur?

6. Explain how you plan for and incorporate real-world problem solving or projects into the curriculum?

7. How are careers incorporated into your instruction?

8. How do you teach 21st Century workforce skills?

9. What types of STEM extracurricular activities are available?

10. How is technology incorporated into your instruction?

11. How do you incorporate performance based assessments?

12. How do you assess 21st Century workforce skills?

The responses were evaluated for themes using open coding across each school to determine the STEM model that is demonstrated. Responses were examined for each school and also compared the responses across schools based on the depth of STEM integration that was determined by the initial questionnaire. In addition to the responses, artifacts were collected from the participants that reflected STEM integration. This served as triangulation to ensure accuracy in the responses as a member check and to provide evidence to the responses.

**Focus Group Findings**

Upon examination of all of the responses from each school, a trend was established for each school’s responses using open coding. In School A’s responses, the participants offered specific examples of ways they were integrating, as well as specific instruction and assessments that were
connected to standards, curriculum, or a group of students. School B’s responses were futuristic in thought as the participants often mentioned ideas they wanted to implement or problems they face in integration. School C’s responses seemed to be focused on school wide STEM integration while offering the experience of STEM absent of any connection to grade-level standards, curriculum, or a particular group of students.

Because of the patterns that emerged during the open coding process, all responses were examined through axial coding based on the specificity of the statement. These codes include: specific, broad, and developing. Through this axial coding, ratios could be offered as support of each model type. Statements that included a specific standard, group of students, or curriculum were placed in the ‘specific’ category. Statements that spoke of all students participating or were not specific in their use were categorized in the broad category. Statements that mentioned activities or thoughts for the future were categorized as developing. Figure 4.4 demonstrates an example of the analysis of the focus group question of “How does planning for STEM occur?” during the axial coding process for all schools.
What are the main components to your STEM integration?

School A

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>It meets the standards.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>…pull in soft skills.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make sure it connects to we</td>
<td>Make sure it connects to we</td>
<td></td>
</tr>
<tr>
<td>are doing in science, reading,</td>
<td>are doing in science, reading, and math</td>
<td></td>
</tr>
<tr>
<td>and math</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

School B

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>We need more materials.</td>
<td>We need more materials.</td>
<td>Time is a big factor.</td>
</tr>
<tr>
<td>Time is a big factor.</td>
<td></td>
<td>…not get the standards taught.</td>
</tr>
<tr>
<td>…not get the standards taught.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

School C

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>butterfly garden in the library</td>
<td>4th and 5th grade do more in the lab.</td>
<td>It is a matter of scheduling for K-3…</td>
</tr>
<tr>
<td>Last year, we had a STEM class</td>
<td>Kids are excited when they hear we are</td>
<td></td>
</tr>
<tr>
<td>once a week.</td>
<td>are going to the lab.</td>
<td></td>
</tr>
<tr>
<td>Library is great at incorporating activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>…able to computers, printers to implement STEM activities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How do you incorporate STEM professionals?

School A

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>We pulled lessons to go with our standards this week and had a professional to go with it.</td>
<td>We pulled lessons to go with our standards this week and had a professional to go with it.</td>
<td>Sometime we have them</td>
</tr>
</tbody>
</table>
judge projects.

### School B

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>...architecture in math</td>
<td>Things we don’t have time for…</td>
<td></td>
</tr>
</tbody>
</table>

### School C

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wacker has come and did some science experiments.</td>
<td>Olin is Best Partner. They send people to do things.</td>
<td>The high school said they will send students to work with kids.</td>
</tr>
</tbody>
</table>

Had a job fair with different professionals come in.

What types of professional development have you received regarding STEM integration?

### School A

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning Days</td>
<td>Classroom stuff</td>
<td></td>
</tr>
<tr>
<td>Team Planning</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### School B

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatlinburg convention had an hour workshop class.</td>
<td>Previous school…project based learning</td>
<td>Never received</td>
</tr>
</tbody>
</table>

Those things are extra that you do in the summer.

### School C

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Someone came last year and did a half year in-service.</td>
<td></td>
<td>Money earmarked for professional development from the lab, but it hasn’t been used yet.</td>
</tr>
<tr>
<td>Sponsored Code.org workshop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture in the Classroom</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Who are the major contributors of STEM at your school?

**School A**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>We have a teacher who is the STEM coordinator.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School B**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is no particular person.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School C**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; grade teachers with science club</td>
<td></td>
<td>No one has time for it.</td>
</tr>
</tbody>
</table>

How does planning for STEM occur?

**School A**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small groups and large groups to decide what standards are and how to integrate them</td>
<td>Started out weekly but it became too much, so now we plan every 9 weeks.</td>
<td></td>
</tr>
</tbody>
</table>

STEM meetings for planning as a whole school.

**School B**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>It does not occur</td>
</tr>
</tbody>
</table>

More flexibility in 4<sup>th</sup> and 5<sup>th</sup> grade

One factor of us not doing it is fear of not being on schedule.
School C

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Went to the food bank</td>
<td>It is in its early infancy.</td>
<td></td>
</tr>
<tr>
<td>I do math and science and if I see where I can incorporate it I will.</td>
<td>It’s hit or miss. No structure</td>
<td></td>
</tr>
</tbody>
</table>

Explain how you plan for and incorporate real-world problem solving or projects into the curriculum.

School A

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Christmas, we talked about recycling, so we talked about how to make an overabundance of garbage new.</td>
<td>Used the drought in California to figure out how to reuse water.</td>
<td>For higher groups, use websites to take current events such as hurricanes.</td>
</tr>
<tr>
<td>We learn about continents so for Africa we are going to engineer a water reservoir.</td>
<td>Brought in pictures of Wacker and Westinghouse and showed them how to use math.</td>
<td></td>
</tr>
</tbody>
</table>

School B

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>In math, you can use grocery store math and putting things in context.</td>
<td>Cereal box</td>
<td></td>
</tr>
<tr>
<td>Reading seems like the easiest to make connections.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>We did Cherokee Indians and someone who knows about them shared information.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
School C

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lego Robotics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butterfly Garden</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How are careers incorporated into instruction?

School A

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>We do this all week with storms and weather…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>We discuss what you would do if you were an engineer.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Our weekly stories tie in really well especially the science units. We talk about the different professions for each science topic.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

School B

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career Fair</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Our reading stories talk about careers.

School C

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching a lesson, I talk about how they will use them in the real world like building a building during area and perimeter.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count money, pay bills, etc,</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How do you teach 21st Century workforce skills?

**School A**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teach them how to collaborate, communicate.</td>
<td></td>
<td>Kagan Strategies</td>
</tr>
<tr>
<td>Teach them to use accountable talk.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School B**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>In kindergarten, we work on our speaking voice through think, pair, share.</td>
<td>It’s hard to apply in elementary schools.</td>
<td></td>
</tr>
<tr>
<td>Anytime they work with groups, we have conversations about how to handle working with others.</td>
<td></td>
<td>One man skit</td>
</tr>
<tr>
<td>We work on perseverance. If you don’t know the answer, you can skip it and come back.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School C**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olin said students need to know how to show up, on time, and drug free.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>You can teach the kids the same thing and none of them turn out the same.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some people have a desire to do better, work hard, and others do not.</td>
<td></td>
<td>Some students feel they are smart, so they don’t need to try while there are special ed students who give more effort.</td>
</tr>
</tbody>
</table>
What types of extracurricular STEM opportunities are available?

**School A**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM Night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM Club</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Robotics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online Scrapbooking</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School B**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Club</td>
<td></td>
<td>Resources is what keeps most people from doing anything after school</td>
</tr>
<tr>
<td>Math Night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM Night</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School C**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lego Robotics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math Night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM Night</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How technology incorporated into your instruction?

**School A**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online Binder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smartboards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clickers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School B**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math fluency, Kahoot, research, PPT</td>
<td>I have some kids that are really low and they can work on their level.</td>
<td>I feel like if we had one to one we could do much better.</td>
</tr>
</tbody>
</table>

They are specific to a task so you may not know how to use...
School C

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper grades doing a lot with Google accounts</td>
<td>Chrome books</td>
<td>School has technology if you want to use it.</td>
</tr>
<tr>
<td>IPads in the library and computer lab</td>
<td></td>
<td>I’m not skilled at using it enough.</td>
</tr>
</tbody>
</table>

How do you incorporate performance-based assessments?

School A

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>We did last year with the solar system. They chose a project.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Our students have to do culminating tasks on Fridays where they use what they learned to complete a task.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

School B

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten has standards based report cards.</td>
<td></td>
<td>I have done it in the past and enjoy it.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I wish we had standards based report cards in 1st grade.</td>
</tr>
</tbody>
</table>

School C

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>I use alot rubrics in the library.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab experiments</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How do you assess 21st Century workforce skills?

**School A**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If they disagree, just watching how they solve it.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowing them to problem solve.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School B**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is not assessed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School C**

<table>
<thead>
<tr>
<th>Specific</th>
<th>Broad</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking around and monitoring and giving verbal feedback</td>
<td></td>
<td></td>
</tr>
<tr>
<td>It’s not on end of year testing, so we don’t do it.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>We don’t have resources to teach typing.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

School A had the most STEM integration occurring based on the questionnaire. Participants from this school provided specific responses to each of the questions that were tailored to direct alignment to curriculum, standards, instruction, and students. This model is called the Directly Integrated Model. For example, a teacher response included, “This week, we took our standards, and we pulled lessons that would go with that and have a STEM professional come in to discuss it with the students.” The response indicates that STEM integration is specific to the standards being taught in the classroom, and the STEM professional is meant for the particular group of students. During the axial coding process, the salient ideas regarding instruction, assessment, and culture were determined. After each school was properly coded based on the specificity of
the comments, an average of specific, broad, and developing statements were calculated for each school. Out of 36 statements that were provided by the participants in School A, 30 (83%) of the statements were specific in content, six (17%) were broad statements, and no statements were in reference to the future or developing. As noted in Figure 4.5, the Directly Integrated Model is composed of specific connections to a particular curriculum, standard, or group of students that required planning and execution. Figure 4.5 shares examples of these statements from School A’s focus group interview and artifacts that were provided.

**Figure 4.5**

*Directly Integrated Model*

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Assessment</th>
<th>Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>“It meets the standards.”</td>
<td>“Sometimes we have them (STEM professionals) judge projects.”</td>
<td>Planning Days</td>
</tr>
<tr>
<td>“Make sure we are pulling in soft skills.”</td>
<td></td>
<td>Weekly Team Planning</td>
</tr>
<tr>
<td>“Making sure it’s tied to what we’re doing in science as well as reading and math.”</td>
<td>Solar System Projects</td>
<td>STEM Fellowships</td>
</tr>
<tr>
<td>“…we took our standards, and we pulled lessons that would go with that…”</td>
<td>Observation</td>
<td>STEM Team</td>
</tr>
<tr>
<td>“In 3rd grade, we learn about continents so for Africa we are going to try to engineer some type of water reservoir.”</td>
<td></td>
<td>STEM Coordinator</td>
</tr>
<tr>
<td>“I tell them if they’re going to be an engineer, this is what engineers do, and I talk about it all week.”</td>
<td></td>
<td>STEM Night</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After school STEM classes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Robotics, Online Scrapbooking, STEM Club)</td>
</tr>
</tbody>
</table>
School B, which had the least depth of STEM integration among the schools, provided responses that illustrated developing ideas about STEM integration. The responses were constructed in future terms rather than in the present. This model is called the Developing Integration Model. In this model, a few classrooms or teachers will do some hands-on projects, but time and resources seem to be a deterring factor. For example, a teacher response included, “We may spend a lot of time on a project and not get any standards taught.” The Developing Integration Model is marked by the ‘pockets’ of STEM that are occurring through ‘in the moment’ connections rather than through planning; however, overall, the school is in a phase of identifying problems and solutions for integration for future integration. During the axial coding process, 16 of 38 (42%) of the statements were specific in nature, four of 38 (11%) were placed in the broad category, and 18 of 38 (47%) were in reference to the future. Figure 4.6 illustrates this through examples from the focus group conducted with School B and the artifacts provided.
### Figure 4.6

**Developing Integration Model**

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Assessment</th>
<th>Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Time is a big factor.”</td>
<td>“That’s what we have in kindergarten (performance based assessments). Our report card is standards based so they have to do things on the spot when I ask.”</td>
<td>“I have never received any (professional development).”</td>
</tr>
<tr>
<td>“We just need more materials.”</td>
<td>“We do not assess workforce skills.”</td>
<td>“Those type of things (professional development) are extra that you have to do in the summer.”</td>
</tr>
<tr>
<td>“Spend a lot of time on a project and not get the standards taught.”</td>
<td></td>
<td>“Fourth and fifth grade have more flexibility so we try to do something one a nine weeks.”</td>
</tr>
<tr>
<td>“No one has time for it.”</td>
<td></td>
<td>“One factor of not doing it is teacher fear of doing something different that is not on the schedule and getting observed.”</td>
</tr>
<tr>
<td>“In math, you can use grocery store math and putting things in context.”</td>
<td></td>
<td>We do that (incorporate careers) at the end of the year with career fair.”</td>
</tr>
<tr>
<td>“Reading seems like the easiest to make connections because a lot of the stories have to do with the real experiences.”</td>
<td></td>
<td>“Resources are what keeps people from doing anything after school. There is no money to buy things.”</td>
</tr>
<tr>
<td>“I always do a one man skit where I am the worker and the boss.”</td>
<td></td>
<td>STEAM Night</td>
</tr>
</tbody>
</table>

School C provided responses that were general in terms of STEM instruction and culture. The responses were constructed to refer to the school as a whole or broad projects removed from standards, curriculum, or groups of students. This model is identified as the Broad Integration Model. For example, a teacher response included, “STEM integration is hit or miss. There is no structure.” This quote demonstrates the exclusivity of STEM integration in reference to
instruction, assessment, and culture. STEM integration is occurring in the school; however, when or how it is occurring is not defined. During the axial coding process, School C made 42 statements: 40% were specific, 29% were broad, and 31% referenced the future. Figure 4.7 illustrates the general nature of the Broad Integration Model through the participant responses and artifacts provided.

**Figure 4.7**

*Broad Integration Model*

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Assessment</th>
<th>Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Fourth and fifth grade do more in the lab.”</td>
<td>“A lot of projects I do through library time, I use rubrics and give results to teachers.”</td>
<td>“Last year we had a STEAM class and all went once a week.”</td>
</tr>
<tr>
<td>“The librarian has been great at incorporating STEM activities during library time.”</td>
<td>“Lab experiments we’ve done in math and science.”</td>
<td>“Our business partner has come and did some science experiments with girls during engineering week.”</td>
</tr>
<tr>
<td>“We did a butterfly garden. By doing it during library, every child in the school were able to experience it by having it in a common area. This helps to fill some gaps.”</td>
<td>Observation</td>
<td>“Had a job fair with different professionals coming in. Kids went around to different stations to talk with professionals.”</td>
</tr>
</tbody>
</table>

| | | “It’s hit or miss. There is no structure.” |
| STEM Night | |

Through the examination of the axial coding of specific, broad, and developing, the frequency of statements were quantified based on their specificity. An average for each of the categories was calculated for each of the schools. School A has a 40% increase in the number of specific responses to STEM integration than Schools B or C. It did not render any developing
responses to any of the questions. School B had 47% of its responses in the developing category, with 42% being specific statements and 11% being broad statements. School C was more evenly distributed than previous schools. It had a majority of statements in the broad (29%) and developing categories (31%) combined at 60%, with 40% being specific. Figure 4.8 illustrates the difference among the models in reference to their responses.

**Figure 4.8**

*Comparison of Statement Types Across Schools*

<table>
<thead>
<tr>
<th></th>
<th>School A- Directly Integrated Model</th>
<th>School B- Developing Integrated Model</th>
<th>School C- Broadly Integrated Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific</td>
<td>83%</td>
<td>42%</td>
<td>40%</td>
</tr>
<tr>
<td>Broad</td>
<td>17%</td>
<td>11%</td>
<td>29%</td>
</tr>
<tr>
<td>Developing</td>
<td>0%</td>
<td>47%</td>
<td>31%</td>
</tr>
</tbody>
</table>

Each question was disaggregated for each school based on its statement types, as well as analyzed the question with consideration for all schools. Percentages were calculated for each question had based on the specificity of specific, broad, and developing. Figure 4.9 illustrates the types of responses given for each question.
Figure 4.9

Statement Types Based on Questions

School A

School B

School C

Legend:
- Specific
- Broad
- Developing
School A had no comments that were developing, and three questions were broad statements. Across all schools, Questions 1-5 (culture) had the most variance regarding response types. Questions 6 and 7 were 100% specific in their response. The topics for these questions include real-world problem-solving and career integration during instruction. Questions 4 and 5 had the highest percentage among the schools to be in the developing range. These questions addressed the major contributors for STEM integration at the school and how planning occurs.

The focus group responses were triangulated with the questionnaire responses to examine similarities and differences. The 1-3 scale used for the questionnaire was used as the data points to be correlated with the focus group data. The focus group data were coded in a similar manner as the questionnaire data to be able to compare the two pieces of data equally. Specific comments were coded with a 3, broad statements were given a two, and developing statements received a one. An average was generated for each question for each school and for all schools.

Figure 4.10 illustrates the alignment between the questionnaire and the focus group responses for individual schools and all schools combined. The value in Figure 4.10 is the distance between the average participant response on the questionnaire and the average response type for the focus group. For example, the question regarding integration of real-world projects from the questionnaire for school A was 2.5 and the focus group value of the response type was a 3.
because School A gave 100% specific response types. The difference between the two scores was a .5. This data allowed for an examination any connections between the perceived depth of integration and the model of integration.

**Figure 4.10**

*Questionnaire and Focus Group Alignment Based On Topic*

<table>
<thead>
<tr>
<th></th>
<th>All Schools</th>
<th>School A</th>
<th>School B</th>
<th>School C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real World</td>
<td>.57</td>
<td>.5</td>
<td>.95</td>
<td>.75</td>
</tr>
<tr>
<td>Technology</td>
<td>.76</td>
<td>.11</td>
<td>1.17</td>
<td>1</td>
</tr>
<tr>
<td>Professional</td>
<td>1.2</td>
<td>.84</td>
<td>1.4</td>
<td>1.35</td>
</tr>
<tr>
<td>Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extracurricular</td>
<td>.85</td>
<td>1</td>
<td>1.18</td>
<td>.38</td>
</tr>
<tr>
<td>Problem-Based Learning</td>
<td></td>
<td>1.1</td>
<td>.75</td>
<td>.75</td>
</tr>
<tr>
<td>Planning</td>
<td>.84</td>
<td>.5</td>
<td>.77</td>
<td>1.25</td>
</tr>
<tr>
<td>21st Century</td>
<td>1.28</td>
<td>.5</td>
<td>1.35</td>
<td>2</td>
</tr>
<tr>
<td>Skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM Professionals</td>
<td>.98</td>
<td>1</td>
<td>.93</td>
<td>1</td>
</tr>
<tr>
<td>STEM Careers</td>
<td>.79</td>
<td>1.1</td>
<td>1.08</td>
<td>.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8.13</strong></td>
<td><strong>6.65</strong></td>
<td><strong>9.58</strong></td>
<td><strong>7.68</strong></td>
</tr>
</tbody>
</table>

In evaluating the comparisons, real-world problem-solving and use of technology were closest among all schools to be similar in scoring between the questionnaire and the focus group responses. 21st Century skills had the most discrepancy between the questionnaire and the focus group responses. School A, the directly integrated model, had the least difference between the
two pieces of data, while School B, the developing integrated model, had the most differences between the data collection types.

**Artifacts**

A variety of artifacts were collected from each school. These artifacts include lesson plans, event flyers, grants, etc., that represented the ideas that the teachers spoke of during the focus group conversations. The majority of the artifacts were from School A, with 12 different artifacts. School B supplied the least number of artifacts. Figure 4.11 shows the artifacts provided by each school.

**Figure 4.11**

*Artifacts Provided*

<table>
<thead>
<tr>
<th></th>
<th>School A</th>
<th>School B</th>
<th>School C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson plans</td>
<td>4</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Performance Tasks</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Grants</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Event Flyers</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pacing Guides</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>3</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>

The artifacts provided were used as examples for the ideas discussed by the participants. The lesson plans, performance tasks, and pacing guides were labeled as specific because they pertained to a standard, curriculum, or a particular group of students. School A was able to provide seven specific examples, School B had one specific example, and School C provided three specific examples. The grants and event flyers were designated as broad because they were
not meant for all students. School A provided five, School B provided two, and School C provided three. This data supports the previous data collected that School A has the most depth for STEM integration, as well as specific integration because this school provided numerous examples of specific integration. Data also suggests that the least amount of integration occurs in School B because this school provided the fewest number of artifacts. School A was the only school that provided a pacing guide for the year in order to integrate STEM. This demonstrates the level of planning regarding integration for School A compared to School B and School C.

Summary

The focus of this study was to determine the models of STEM integration used by elementary schools due to the limited research for this age range. The data illustrated three types of models that reflected degrees of STEM integration in the areas of instruction, assessment, and culture: Directly Integrated Model, Broadly Integrated Model, and Developing Integrated Model. The three models were established based on the level of specificity provided during responses regarding different components of STEM integration. The Directly Integrated Model incorporates STEM with the standards, curriculum, and specific students at the forefront of planning. The Broadly Integrated Model exposes students to STEM activities and experiences; however it is most often void of standards, curriculum, and specific students. The Developing Integrated Model encompasses future ideas for STEM integration with some broad STEM integration occurring. Based on the data, there are targeted areas of strength and weaknesses for each school for STEM integration due to the level of implementation for the different components in culture, instruction, and assessment. The specificity of the responses were correlated to the depth of integration for each school, and the artifacts provided contributed further evidence to the models determined in this study.
CHAPTER 5: CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

STEM education is becoming an educational focus in the United States, especially due to the United States’ scoring in the middle or behind other developed countries ranking, 38 of 71 countries that took the Program for International Student Assessment (PISA) in 2015 (DeSilver, 2017). The need for STEM education is becoming a rising concern so graduating students can be competitive in the global STEM market.

The goals of STEM integration are to ensure that STEM workers are available in the future who can problem solve and maintain a level of progression in science, technology, engineering, and math (Ehler & Udall, 2008). Schools are a primary source of exposure for many students in developing their interests and knowledge in these areas. Early exposure to STEM education is important to career development, and elementary schools are beginning to integrate STEM in different ways and at different levels (Vilorio, 2014). Little research has been conducted regarding elementary school STEM integration. Most researchers examine middle and high school STEM integration programs for their models and level of success. The purpose of this phenomenological study was to examine the models for STEM integration at an elementary school level, which could serve as a guide to schools considering the STEM implementation process and further research in this area. When teachers are provided training regarding models of STEM integration, they are more likely to modify their teaching (Levitt, 2001). To discuss the findings of this study, this chapter is divided into four sections: summary, conclusions, implications, and recommendations for future research.

Summary

The conceptual framework for this study is predicated upon the situated cognition theory, which posits that learning should be real world and relevant for understanding to occur. Students
are able apply their learning through an apprenticeship model where learning is placed in context (Collins, 1988). This theory corresponds with the basis for STEM education and integration. Students are utilizing their learning in ways that will prepare them for the 21st Century workforce with hands-on experiences, usually through problem-based or project-based learning. The basis for the questions in this study and the coding system used were developed via this framework of ideas.

The study was guided by with one research question: What models for instruction, assessment, and culture are elementary schools utilizing to implement STEM integration?

This study was phenomenological, qualitative research in which a questionnaire, focus group interviews, and artifacts were utilized to develop the models identified for STEM integration. The participants were from a rural school district in Southeast Tennessee. Three schools were identified that shared an interest in STEM integration, which were chosen as a result of their mission statements or current concentrations. The expectations presented by a school’s mission statement becomes the expectations of the school’s culture (Scott, 2012). The research began with an online questionnaire to all faculty of each school. Participation in the questionnaire was voluntary, which resulted in varying numbers of completed questionnaires from each school. Then, each school participated in a focus group semi-structured interview. Participants were chosen by the principal of each school. These participants were all asked the same 12 questions that are more elaborative in nature than the questionnaire statements, which included items regarding STEM integration in school culture, instruction, and assessments. The questions guided the development of STEM integration models. Artifacts were also collected from each school. Participants believed these artifacts were relevant to the STEM integration
that was occurring at their school. The artifacts helped in the member check process and triangulation of data.

All pieces of data were analyzed. The questionnaire responses were coded with a scale of 1-3 to determine a numeric value for the depth of integration for each school. It was determined that School A has the most depth of integration, while School B has the least depth of integration. The focus group data were analyzed beginning with an open coding system from which identified common themes in each school based on the participant responses. The responses ranged from broad to narrow statements. For example, some statements gave mention to specific standards, curriculum, or students; while other statements described a general activity that was based in STEM but void of standards, curriculum, or standards. An axial coding system was used, in which each statement was coded with the following terms: specific, broad, and developing. School A participants offered the most specific type comments, School B participants responded with many developing statements, and comments from School C participants were in the broad range. The artifacts provided supporting evidence for the categories and each school’s designation within each category. School A participants were able to provide several examples, such as lesson plans, that gave credit to the specific comments they made during the focus group interviews. The lesson plans provided examples of STEM integration with standards and a particular group of students as a part of the planning. School B participants were able to provide few artifacts, and all examples were broad in nature, such as a flyer for STEM night. School C participants contributed a mix of the specific artifacts, such as rubrics and broad artifacts like STEM Night. After the analysis of all data, three models for STEM integration were determined in response to the research question: Directly Integrated Model, Broadly Integrated Model, and Developing Integrated Model. These three models are
based on the data collected from each school. School A is an example of the Directly Integrated Model, School B reflects the Developing Integrated Model, and School C demonstrates the Broadly Integrated Model. The names created for these models are in reference to the specificity degree of STEM integration as reflected by each school.

Conclusions

Axial coding supported three models of STEM integration in response to the following research question: “What models for instruction, assessment, and culture are elementary schools utilizing to implement STEM integration?” The Directly Integrated Model is supported by a school’s ability to tailor STEM integration to the standards needing to be taught, the curriculum being used, and/or a particular group of students. Classroom teachers and special area teachers, such as librarians, music teachers, physical education teachers, and additional instructors begin with the necessary instruction, then create the STEM integration around the instruction. The planning component, which connects to the culture of the school, was more developed in this model than the others. The culture of the school allowed and stressed the inclusion of STEM integration planning during weekly grade-level meetings. It also provided specific opportunities to plan for STEM integration, such as during half-day planning days. Professional development that allows teachers time to plan and create their materials leads to greater integration (Avery & Reeve, 2013). The school culture also stressed the importance of integration through the amount of professional development it provided, which was apparent in the questionnaire data. The artifacts also support the importance of planning and professional development in the Directly Integrated Model. School A, which demonstrates the Directly Integrated Model, provided lesson plan templates and pacing guides, which furnishes evidence to the forethought of integration.
The Broadly Integrated Model, as reflected in School C, is quite general in terms of the school’s STEM integrative culture, instruction, and assessment. The teacher has a STEM lesson he/she would like to incorporate, then the needed instruction or standards are organized around the STEM lesson. While standards may be taught during the STEM lesson, they are not the emphasis of the lesson. Instead, the lesson is more focused on the experience. Necessary standards must be discussed so that teachers can make important connections between state standards and STEM integration practices (Avery & Reeve, 2013). In this model, many students of varying grades are exposed to the lesson. The majority of STEM integration that occurs is during special area classes, such as library. This model had some specific integration and developing integration qualities. As stated by one participant, “It’s hit or miss. There is no structure.” The culture does not support the planning for STEM integration. Teachers may incorporate STEM when there are simple or easy connections to STEM that do not require much planning. All models had some broad integration occurring, such as STEM nights, after school STEM classes, or career fairs.

The Developing Integration Model, as revealed in School B, does not have specific ways of integration. There are ideas and hopes for integration, but the problems and solutions have yet to be developed. Some teachers will conduct STEM activities void of standards and curriculum in their classroom. Teachers are not provided the resources of materials, time, or training to integrate STEM. Professional development trainings were perceived to occur less frequently than the other two models. The culture for STEM integration has not emphasized STEM integration for the time and effort dedicated to teacher training. The National Research Council (2011) suggests that the narrowing of the curriculum is responsible teachers’ abilities to integration STEM. This model was higher than the other models in technology instruction. This
may be due to understanding of technology instruction or amount of technology available (Hsu, Purzer, & Cardella, 2011). This aspect of STEM instruction is different from school to school due variability of resources. Knowledge of technology, resources, and time were deterring aspects for its use.

There were some commonalities among all three models, such as high integration for real-world problem solving and the incorporation of careers. These two components, while important for STEM integration, are also considered best practices for teaching regardless of a STEM focus (Sole, 2015). Many teachers implement these two components without extra training or planning. Kagan strategies were also referenced by all schools to instruct 21st Century skills. Kagan strategies are reflective of 21st Century skills because they prompt the use of collaboration, communication, and problem solving (Wagner, 2008). All models use project-based learning as a method for assessment and observation. Teacher understand the importance of hands-on, real world context to the motivation and understanding of learning, which is reflected in problem based learning (Merrit, et al., 2017). These structures are often considered as best practices by irrespective of their relevance to STEM, so their uses in all models is not surprising. These strategies were a part of a district-wide focus, which correlates to their use by all schools. Professional development was the lowest scoring component for all three models.

The Broadly Integrated Model and the Developing Integrated Model share common characteristics; however, the defining factor is the ability to resolve problems with integration.

All three models share a similar interest in problem based learning, career instruction, and after school STEM programs. They utilize these at a similar depth, and their focus group discussions were the same. The ease of integrating these components may be a contributing factor in this similarity. However, there are several differences. The Directly Integrated Model
focuses on the standards in a STEM lesson; while the Broadly Integrated Model and Developing Integrated Model focus on the STEM experience with the standards as a possible integration.

The regularity of integration is another notable difference among the models. The progression ranges from very little integration to no structure in the frequency, then a regular occurrence. The frequency of planning and professional development is another component that creates differences. The Directly Integrated Model has regular planning and professional development, the Broadly Integrated Model has intermittent planning and professional development, while the Developing Integrated Model has no planning nor professional development. The difference among these necessitate a culture shift that requires more time and effort to accomplish from an administrative perspective. Lastly, the Directly Integrated Model and Broadly Integrated Model have provided resources of time, training, and materials, while the Developing Integrated Model does not. Fiscal resources are another cultural shift that requires a mindset change.

**Implications**

There are several implications from the findings of this study. The most prominent is the importance of planning and school culture in the development of a STEM integration model. School A had the most time and focus for the planning of STEM integration. Teachers in School B, the Developing Integrated Model, believed that STEM integration would be an extra component that they did not have time to integrate. These teachers also suggested they would ‘be in trouble’ for not doing what was on their schedule. An administrative stress on STEM integration through the use of planning would allow for a culture change in which the teachers felt integration was expected. Teachers in the Directly Integrated Model use STEM integration as a means to teach their standards and curriculum, which alleviates the stress of an additional planning component. Rather than STEM being an extra lesson, it becomes the caveat for the
lesson. This mindset is a shift that seems to occur between the Broadly Integrated Model and the Directly Integrated Model. Without this shift in mindset, STEM integration will not become a regular, structured occurrence in a school. For STEM integration to become a common practice, it must be used consistently and at the core of instruction (Bybee, 2013). The professional development that occurs is also a cultural component to each model. The Directly Integrated Model allowed time for professional development, which gives teachers an impression that it is important and expected. The teachers in this model sought their own professional development opportunities, including STEM fellowships, summer workshops, and experts in the field. The teachers in the Developing Integrated Model indicated that this type of development could only occur as an extra summer activity. Because School A and School C were in the same district, the opportunity for professional development were the same; thus this aligns to a cultural shift that occurred in the Directly Integrated Model. Professional development was the lowest scoring component for all models as it was perceived by the teachers participating in the questionnaire. This illustrates a more general, district-wide cultural sense of the importance for STEM integration. Additional emphasis on STEM integration by the district would increase the frequency of professional development for all three schools.

Another factor that determined a school’s ability to transition from the Developing Integrated Model to the Broadly Integrate Model was the ability to recognize problems and approach these problems with a solutions-oriented mindset. While the identification of problems is necessary, the school must consider what is currently working and build upon these successes (Priest & Gass, 1997). The Directly Integrated Model did not have any statements that were developing, futuristic, or reflective of problems. Each comment from the teachers in School A were specific regarding their activities. The School B, which demonstrated the Developing
Integrated Model, however, had a majority of its comments as developing. Comments such as, “Resources is what keeps most people from doing anything after school. There is no money to buy things with, so we have to buy it ourselves.” Each of the research schools are in the same district, so monetary resources and materials are similar for each school. This mindset is a cultural component that hinders progression to the next model.

In the examination of the three models, a hierarchy of progress is implied based on the depth of data and specific integration. Because School B had the least amount of integration occurring, this is considered the basic model where schools beginning the integration journey may start. Once a cultural shift occurs in mindset to a solutions-oriented focus, this allows the Broadly Integrated Model to be resolved. As teachers become familiar with integration and the culture of the school places more of an importance on STEM integration through planning and professional development, the top tier of integration, the Directly Integrated Model, can be acquired. Teachers utilize STEM integration as a means for instruction rather than an extra lesson they incorporate into their weekly plans.

**Recommendations**

Future research could include different demographics because this study only considered schools within one Southeast Tennessee school district. Diversifying the districts within the study would help to ensure district incentives are not a variable. Due to a convenience sample population, the database for school selection was limited; thus research of schools with a similar depth of integration could be conducted. Different models could exist within schools of the same level of integration. Another aspect to research as an extension of this study is the examination of assessment data and success related to each model. Many schools considering the implementation of STEM inquire about how it impacts standardized testing data.
Summary

A gap exists in research for STEM integration in elementary schools from previous studies. This study sought to fill the gap with the research question: What models for instruction, assessment, and culture are elementary schools utilizing to implement STEM integration? The data collection process included a questionnaire, focus group interviews, and artifacts. The questions asked during the questionnaire and focus groups referenced to STEM instruction, assessment, and culture. The data collected supported three models of integration to include Directly Integrated Model as reflected in School A, Broadly Integrated Model based on School C, and Developing Integrated Model as demonstrated by School B. The degree of specificity for each response was coded from each school’s responses to determine each of the models.
References


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APPENDIX A

STEM Questionnaire

STEM Integration

Please answer each question from your perspective. This survey is completely anonymous, and your participation is greatly appreciated!

* Required

How often are STEM professionals invited to work with students? *
- Never
- Seldom (about 1 time per semester)
- Sometimes (1-3 times per semester)
- Often (4 or more times per semester)

How often do students participate in real world projects or activities? *
- Never
- Seldom (2 times per year)
- Sometimes (2 times per semester)
- Often (4 or more times per semester)

How often do you receive professional development regarding STEM integration? *
- Never
- Seldom (1-2 times per year)
- Sometimes (2-3 times per semester)
- Often (4 or more times per semester)

How often are careers discussed during instruction? *
- Never
- Seldom (once a month)
- Sometimes (weekly)
- Often (Daily)

How often do you integrate technology as part of your instruction? *
- Never
- Seldom (Monthly)
- Sometimes (Weekly)
- Often (Daily)

How often is STEM a part of extracurricular activities? *
- Never
- Seldom (1-2 opportunities are offered)
- Sometimes (3-4 opportunities are offered)
- Often (5 or more opportunities are offered)
How often do students utilize 21st Century workforce readiness skills?  
(problem solving, critical thinking, collaboration, perseverance, etc) *
  
  o Never  
  o Seldom (monthly)  
  o Sometimes (weekly)  
  o Often (daily)

How often do students engage in problem based learning? *
  
  o Never  
  o Seldom (1-2 times per semester)  
  o Sometimes (monthly)  
  o Often (weekly)

How often do you discuss STEM integration during lesson planning? *
  
  o Never  
  o Seldom (2-3 times per semester)  
  o Sometimes (monthly)  
  o Often (Weekly)

Which school are you a part of and what is your role (teacher, administrator, support staff)? *
Focus Group Transcription

What are the main components to your STEM integration?

School A

It meets standard

Make sure we’re pulling in soft skills, perseverance, working together, collaboration

Making sure it’s tied to what we’re in science as well as reading and put some sort of math in there

School B

Materials, needing the materials,

Time is the big factor;

Spend a lot of time on project and not get standards taught

School C

4th and 5th do more in lab.

Last year we had a STEM class and all went once a week

We have been able to find those activities to

* has been great in incorporating STEM activities during library time

Before, we got the lab, wrote a grant for arts program. We are able to use computers, printers, etc. to implement some STEM activities

I think K-3 is happening but it’s a matter of scheduling and able to get together. * wrote a grant that goes along with Legos but we are having to wait on various things to be able to put into practice.

Kids are excited when they hear they are going to the lab or doing a certain activity or experience.

Butterfly garden. By doing it the library, every child in the school were able to experience it by having in a common area. This helps to fill in some gaps.

How do you incorporate STEM professionals?
School A
This week we took our standards and we pulled lessons that would go with that and have professional come in to discuss
Sometimes we have them judge projects (we have judge panels)
School B
If you are doing science or architecture or math,
Things we don’t have a lot of time for
School C
* is Best Partner. They send people to do things with our students (put up lego wall)
* has come and did some science experiments with girls (big girls) during engineering week
Had a job fair with different professionals come in. Kids went around different stations to talk with professionals.
* have said they will send in people, students to come in to work with kids

What types of professional development have you received regarding STEM integration?
School A
Planning days
Team planning
Classroom stuff?
School B
Never received
Things like those types of things are extra that you have to do in the summer
Gatlinburg convention had an hour workshop class but it was geared toward 4,5
Previous school that I taught at was a science academy so I had a lot there because project based learning was required.
School C
- came last year and did half day in-service

Sponsored Code.org

Money earmarked under grant for lab for professional development (not scheduled yet)

Went to Agri. In classroom workshop (STEM activities)

Who are the major contributors of STEM at your school?

School A
A teacher within the school is the STEM coordinator.

School B
4th grade teachers with science club
No one has time for it
Especially k-1, there isn’t

School C
There is no one major contributor.
The librarian does a lot with STEM.

How does planning for STEM occur?

School A
Small groups and large groups to decide what our standards are and how we can integrate them
STEM meetings for planning for the whole school
Started out weekly but it became too much (took too long) so we now have scaled it down to once every 9 weeks to plan. And we do small things throughout

School B
It does not occur
More flexibility in 4th and 5th grade
4th and 5th have more flexibility so we try to do something once a 9 weeks. Like we tied it to reading with fairytales we worked on building a boat

One of the factors of not doing it is teachers are in fear of not doing something different that is not on the schedule and getting observed and not doing what is on my schedule. I want to be on task with what is on my lesson plans and curriculum rather than getting observed. If that could be relaxed whether it’s a day or week that you can integrate your STEM but it would have to be stated and on the books. God forbid we interrupt the reading time

**School C**

It is in early infancy (school wide). I hate we are not because these are great development and learning

Went to food bank

It’s “hit or miss”. No structure.

I do math and science and if I can see where I can incorporate, then I will try to do a STEM activity.

**Explain how you plan for and incorporate real work problem solving or projects into the curriculum?**

**School A**

At Christmas we were talking about cycle reduce/reuse. Using real world problems. Explained how we have an overabundance of garbage and how you repurpose that and how you make it into something new

Have also done it with water such as a drought in California, how you’re going to reuse water to grow plants and food (using real world things that are happening)

For higher groups using websites to take current events such as hurricanes and things like that

In 3rd grade, we learn about the continents so for Africa we are going to try to engineer some type of water reservoir

What about in your daily instructions, such as math concept? Is there any real world examples?

Brought in pictures of * and * and showed how they have to use math when they’re engineering

**School B**

In math you can use grocery store math and putting things in context
I don’t plan on it in reading so much but I can do that on the fly. In math though I brought a cereal box that I took apart into a net. * is in my room where he shares real world situations.

Reading seems like the easiest to make connections because a lot of the stories have to do with real experiences

We did the Cherokee Indians and * knew a lot about Cherokee Indians

School C

Felt already discussed previously

How are careers incorporated into instruction?

School A

We do this all week as we research storms and weather and talk about police officers, Emergency management people and what they would do in these situations and we will then bring in professional

We talk about careers so I tell them if they’re going to be engineer, this is what engineers do and I talk about this all week. Example: If you really love fossils, then you need to be a paleontologist. We’re always pulling in those vocabularies and those jobs and how what you’re doing links to those professions

Our weekly stories tie in really well too, especially with science units such as our extremely weather unit, we talked about all different professions

School B

We do that at the end of the year with the career fair

Our reading stories this week was about careers. We have a whole unit on careers

School C

Teaching a lesson (area model of fraction) I talk about how they will use it in real world (ex. Of building a building)

Count money, pay bill, etc.

How do you teach 21st Century workforce skills?
School A

Teach students how to collaborate and communicate (look them in the eye). Teach them how to communicate with each other. You ask them to talk about it and actually walk over to student and make them accountable to talk and and say “oh I think that . . . “ “ I felt differently and here’s how . . . “ so they know its ok to disagree and shows them how to disagree. Speak with your shoulder partners

School B

I feel like its hard in elementary school. Its about teaching them behaviors and how to deal with people. Its hard to apply in elementary

In kindergarten we work on our speaking voice, think pair share, talking with a partner

Any time they work with groups we have to tell them that “Ok sometimes you may not get along with everyone” We have had conversations about how to handle working with others

I always do a one man skit where I am the worker and the boss. What are you going to do when you can’t add or count change. What is your boss going to do? Hes going to say your fired!

We work on perseverance. If you don’t know the answer, you can skip and come back to it. Don’t just sit and stare. Do everything you know how to do then ask for help

School C

Just had a job shadow with plt manager at Olin. Asked what we should be teaching students and his response was “they should show up every day, on time and be drug free”. They need responsible people

In your instructions do you teach them “work ethic”? 

I don’t think there’s a black and white answer. Example, you can have 3 kids, teach the same, similar abilities, but they will have different desires, work ethics.

Some people have desire to do better, work hard. Others do not

You have certain students that feel they are so smart so they have the attitude they don’t need to try. Students in special ed that gives more effort.

What types of extracurricular STEM opportunities are available?

School A

STEM night
STEM club
Robotics
Online Scrapbooking

School B
Science Club
Coding
STEAM Night

Resources is what keeps most people from doing anything after school. There is no money to be things with so we have to buy it ourselves

School C
Lego robotics
Math night
STEM night

How is technology incorporated into your instruction?

School A
Smartboards
Computers
Ipads
Clickers

Is this using and applying technology or learning to use technology?

In 2nd grade, it’s a little of both

Using Online binder. Example of this online binder for the solar system. At the end they will build the system. They could create their own binder, but in 3rd grade, teachers create binder for students access

School B
We have one to one iPads in 4th grade: math fluency, exit tickets, Kahoot, research, projects like making a PPT not everyday, MobyMax, it is outdated so we don’t get to do somethings

I feel like if we had one to one we would do a much better job.

It is nice have one to one because I have some kids that are really low and that is the time they can get things on their level. Its one of the biggest ways for differentiation.

Along with the STEM programs, they are specific to a task so you may not know how to use. You would have to be well versed in some things

School C

Upper grades doing a lot with Google accounts

Chrome books in STEM lab and iPads

Have iPads in library and computer lab

I feel this school has the technology if you want to use it and WIFI works.

I feel it’s all wonderful, but I’m not skilled enough with Google. This is the reason we’re not incorporating more because I’m not comfortable with it yet.

How do you incorporate performance based assessments?

School A

Did last year on the solar system. Had them choose off the project board and bring in any project they selected and they spoke about how they created it

School B

That’s what we have in kindergarten. Our report card is standards based so they have to do things on the spot when I ask.

I don’t mind having an opportunity to give a kid a task and having them work through. I have don’t that in the past and I have enjoyed but you have to have the time

I feel like we could learn so much more. I wish we had standards based report cards in first grade

School C

A lot of projects I do through library thru rubrics (?) I score rubrics and give results to teachers

Lab experiments we’ve done, I incorporate in the math and science

How do you assess 21st Century workforce skills?
School A

Observations. Just watching

If they disagree, just watching how they can solve

Allowing them to problem solve. I like to watch them figure out a problem. Struggling in the appropriate way

School B

No responses

School C

End of year testing and that’s not on it, we’re probably not testing a lot of it

Walking around and monitoring. Giving verbal feedback

We don’t have resources to teach typing
Other Comments

School C

Looking toward future, I would like to really get into STEM if we can make it work the right way.

I think if you pull our staff as a whole, that would be a general census.