Fall 11-2015

The Perceptions of Elementary STEM Schools in Missouri

Kelli Michelle Alumbaugh
Lindenwood University

The Perceptions of Elementary STEM Schools in Missouri

by

Kelli Michelle Alumbaugh

November 2015

A Dissertation submitted to the Education Faculty of Lindenwood University in

partial fulfillment of the requirements for the degree of

Doctor of Education

School of Education

The Perceptions of Elementary STEM Schools in Missouri

by

Kelli Michelle Alumbaugh

This Dissertation has been approved as partial fulfillment

of the requirements for the degree of

Doctor of Education

Lindenwood University, School of Education

Shelly Fransen — 11/11/15

Dr. Shelly Fransen, Dissertation Chair — Date

Sherry DeVore — 11-11-15

Dr. Sherry DeVore, Committee Member — Date

Don Forrest — 11-11-15

Dr. Don Forrest, Committee Member — Date

Declaration of Originality

I do hereby declare and attest to the fact that this is an original study based solely upon my own scholarly work at Lindenwood University and that I have not submitted it for any other college or university course or degree.

Full Legal Name: Kelli Michelle Alumbaugh

Signature: Kelli Alumbaugh Date: 11·11·15

Acknowledgements

I would like to thank my dissertation committee, Dr. Sherry DeVore, Dr. Shelly Fransen, and Dr. Don Forrest, for all the time and encouragement they provided me during my dissertation process. The support and encouragement I received from my committee was unexpected and greatly appreciated. I would like to thank all the individuals who participated in my study and shared their knowledge with me. I would like to thank my husband, Zach, for being supportive through the entire process of finishing my dissertation. Finally, to my family and my friends, thank you for your patience with the many hours I spent completing my dissertation.

Abstract

Science, technology, engineering, and mathematics education, or STEM, is an area that is currently growing in popularity with educators (Becker & Park, 2011). A qualitative study consisting of interviews was conducted and data were gathered from three leaders in professional STEM organizations, four principals from elementary STEM schools, and six teachers from elementary STEM schools to gain their perceptions of elementary STEM schools in Missouri. The perceptions of leaders in professional STEM organizations regarding STEM education were consistently all positive, and each leader was a proponent of STEM education at the elementary level. The perceptions of principals and teachers were also similar in response to interview questions. Both principals and teachers reported STEM education has the ability to increase student engagement and student achievement. The principals provided information that showed a shift in teacher attitude toward STEM from hesitant to giving full support. The teachers offered answers to the interview questions that showed favor and support for continuing professional development in regards to STEM education. Results and conclusions from this study may assist schools in deciding if STEM education should be integrated within their curriculum.

Table of Contents

List of Tables

List of Figures

Chapter One: Introduction

Education is a continually shifting process that requires the integration of new theories and practices on a consistent basis (Chen, 2011). Science, technology, engineering, and mathematics, or STEM education, is an area currently drawing a lot of interest from educators (Chen, 2011). A report at InTech, an educational resource center for science, included, “A successful STEM education provides students with science, math, and engineering/technology in sequences that build upon each other and can be used with real-world applications” (Chen, 2011, p. 3).

Recently, STEM education has captured the attention of educators, because STEM practices are incorporated into the classrooms; students are enabled “to relate their knowledge, skills, and beliefs across STEM disciplines, thus promoting more meaningful science and mathematics learning for students” (Bicer, Navruz, Capraro, & Capraro, 2014, p. 8). Additionally, STEM education is important in order to provide students with a need to achieve and to contribute in a meaningful way toward building a future that thrives (Dugger, 2011). The National Academy of Sciences, National Academy of Engineering, and Institute of Medicine have reported STEM education is linked to sustaining the United States’ current leadership in the scientific world as well as helping maintain its economic power (Bicer et al., 2014).

In this chapter, a historical basis for the research is provided. The conceptual framework, the statement of the problem, and the purpose of the study are presented. The research questions used to guide this study are posed. Additionally, the definitions of key terms, limitations, and assumptions are detailed.

Background of the Study

Since 2001, the STEM acronym has been consistently used by individuals involved in the educational community (Fioriello, 2014). However, an interest in the study of STEM education can be dated back to Benjamin Franklin, who wrote about the need to teach mechanics and grafting, force, and the effect of engines and machines (Salinger & Zuga, 2009). Since the Vocational Act of 1917, the federal government has provided financial support for career and technical education (Salinger & Zuga, 2009). In addition, the National Science Foundation has also been involved with research in STEM education since its formation in 1950 (Salinger & Zuga, 2009). Several researchers have stated the launching of the Soviet Union's Sputnik satellite was a pivotal point for the execution of STEM education policies in the United States (Gonzalez & Kuenzi, 2012). In 2001, Judith A. Ramaley, the former director of the National Science Foundation's education and human-resources division, coined the term STEM education (Fioriello, 2014).

Congress developed an increased curiosity in STEM education in 2007 due to the National Academy's report entitled, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Gonzalez & Kuenzi, 2012). Gonzales and Kuenzi (2012) cautioned, "Perceived weaknesses in the existing U.S. STEM education system—along with other important factors—threatened national prosperity and power" (p. 2). The report in part resulted in the passing of the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act, or the America COMPETES Act, in 2007 (Gonzalez & Kuenzi, 2012).

This was the final educational reform that created the current STEM initiative (Gonzalez & Kuenzi, 2012).

In 2010, the America COMPETES Act was "reauthorized allowing numerous programs designed to strengthen research and education in the United States related to science, technology, engineering, and mathematics" (Federal Inventory of STEM Education, 2011, para. 2). Upon signing the Reauthorization Act of 2010, President Barack Obama specified:

> Maintaining leadership in research and technology is crucial to America's success. But if we want to win the future—if we want innovation to produce jobs in America and not overseas—then we also have to win the care to educate our kids. (as cited in Federal Inventory of STEM Education, 2011, para. 1)

Another aspect of the Reauthorization Act of 2010 was improving achievement of U.S. students and outperforming other countries in math and science over the next 10 years (Federal Inventory of STEM Education, 2011). In a 2011 State of the Union address, the President desired "a new effort to prepare 100,000 science, technology, engineering and math teachers with strong teaching skills and deep content knowledge" (as cited in Federal Inventory of STEM Education, 2011, para. 5). President Obama has been adamant great teaching is a key part of any child's success (The White House, 2013).

According to a report by the International Technology Education Association, STEM education has the potential to create a transformation in the lives of young children and offers students the ability to investigate and analyze real world situations

(Dugger, 2011). Bicer et al. (2014) ascertained there are three main reasons which justify concerns about the status of K-12 STEM education in the United States:

1. Students' science and mathematics test performance, as measured by the National Assessment of Educational Progress (NAEP) showed that students were not proficient in mathematics and science.
2. The size of the mathematics and science achievement gaps between students who come from the traditional upper class and those students who come from diverse ethnic and low socio-economic status backgrounds.
3. Students lack the appropriate knowledge and understanding of basic scientific and mathematical concepts that they face in real life. (pp. 9-10)

Therefore, one of the goals of STEM education is to increase the number of underrepresented students who pursue STEM majors in college (Bicer et al., 2014).

It was estimated by the National Science Foundation 80% of the jobs available in the next few years will entail math and science skills (Fioriello, 2014). Also reported was the fact "15 of the 20 fastest growing fields will require significant math and science preparation" (Fioriello, 2014, para. 3). As a result of this need, the Educate to Innovate campaign was created by President Obama (Federal Inventory of STEM Education, 2011). The goal of this campaign has been to emphasize the importance of math and science through partnering with businesses, universities, non-profit organizations, foundations, and government agencies (Federal Inventory of STEM Education, 2011). By working together, America can continue to compete in the global market (Federal Inventory of STEM Education, 2011).

Chen (2011) indicated, “Children exposed to STEM education at a young age perform better in science and math than students who were not” (para. 6). In addition, “Students who are taught by experienced and well-trained math and science teachers have been shown to outperform students with less experienced teachers” (Chen, 2011, para. 12). Also included in these benefits:

1. Promotes equality in education (STEM benefits both male and female students equally)
2. Teaches independent innovation
3. Allows students to explore subjects at greater depth
4. Helps students develop critical thinking skills. (Chen, 2011, p. 4)

Since there are numerous advantages to STEM education, it is important to reach out and gain support from government leaders, educators, and business leaders (Chen, 2011).

Researchers also reported the following seven reasons why students pursue STEM career fields over others:

1. Good salary right out of school
2. Intellectually challenging
3. Good job potential
4. Student is passionate about field of study
5. Students performed well in these subjects in primary and secondary school
6. To make a difference
7. The U.S. is in need of qualified workers in these fields. (Chen, 2011, p. 4)

Students who graduate from STEM programs often find they are better prepared for college and are on the path to a well-paying career in the science or engineering field (Chen, 2011).

Theoretical Framework

Butin (2010) stated an interpretivism perspective "assumes that the world is not simply out there to be discovered, but an ongoing story told and refashioned by particular individuals, groups, and cultures involved" (p. 60). The introduction of interpretivism in education can be referenced back to the late 1970s (Taylor & Medina, 2013). In addition, an interpretivist perspective "does not attempt to adjudicate between competing truth claims in order to determine the one best answer; rather interpretivism suggests that all one can do is accurately and thoroughly document the perspective being investigated" (Butin, 2010, p. 60). The interpretivist approach allows researchers the ability "to build rich local understandings of life-world experiences of teachers and students" (Taylor & Medina, 2013, para. 8). For this study, an interpretivism theoretical framework was utilized.

By using the interpretivism research perspective, the focus was on the perceptions of STEM schools as reported by elementary principals and teachers in STEM schools and the leaders of STEM organizations. A STEM school centers on the core subjects of science, technology, engineering, and mathematics, and the process of STEM education is more than "simply incorporating these four subjects into a core curriculum" (Chen, 2011, p. 2). There must be "actual integration of these disciplines into a single meta-discipline" in order to be a successful and effective STEM school (Chen, 2011, p. 2).

This study, utilizing the interpretivist approach, involved the determination of the perceptions of elementary principals and teachers in designated STEM schools and the viewpoints of leaders in STEM organizations. The criteria and/or best practices in order to be considered a STEM school were also considered. Butin (2010) emphasized the key goal in the interpretivism theoretical framework is to "search for patterns of meaning" (p. 59). Therefore, the research in this study focused on perceptions of STEM education, utilizing interviews conducted with elementary principals and teachers in STEM schools, as well as the perceptions of leaders in STEM organizations.

Statement of the Problem

Over the past few years, the number of students choosing to major in science or technology-correlated fields has declined (Bicer et al., 2014). If this continues, a shortage in areas of the engineering and science fields will occur (Bicer et al., 2014). In addition, U.S. students are falling in the middle of the pack for math and science achievement when compared to other countries (Federal Inventory of STEM Education, 2011). In a 2011, President Barack Obama declared "a new effort to prepare 100,000 science, technology, engineering, and math (STEM) teachers with strong teaching skills and deep content knowledge of the next decade" (as cited in Federal Inventory of STEM Education, 2011, para. 1). This is a clear indicator the Obama Administration is making STEM education a top priority (Federal Inventory of STEM Education, 2011).

Purpose of the Study

The purpose of this study was to determine perceptions of STEM schools from various viewpoints. According to a report by the website STEMconnector.org, it is estimated that by 2018, 8.65 million workers will be needed in STEM-related jobs (as cited in Hom, 2014). The Committee on Integrated STEM Education, The National Academy of Engineering, and The National Research Council (2014) contended, "Education for students in science, technology, engineering, and mathematics has received increasing attention over the past decade which calls both for greater emphasis on these fields and for improvements in the quality of curricula and instruction" (p. 21). The concern for keeping the United States as the frontrunner in research, innovation, and technology came to fruition with the publication of *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future* (Gonzalez & Kuenzi, 2012). This publication created awareness about the need for additional scientists, engineers, and mathematicians in order for the United States to remain competitive (Gonzalez & Kuenzi, 2012).

Research questions. The following research questions guided the study:

1. What are the perceptions of elementary principals in STEM schools regarding teacher attitude toward the implementation of STEM?
2. What are the perceptions of teachers in STEM schools regarding student engagement?
3. What are the perceptions of teachers in elementary STEM schools regarding professional development?
4. What are the perceptions of professional STEM organizations, elementary principals, and elementary teachers regarding the benefits of elementary STEM schools?

Definitions of Key Terms

For the purposes of this study, the following terms are defined:

Advanced Research Projects Agency for Education (ARPA-ED). This agency was established by President Obama to fund projects performed by industry or universities (President's Council of Advisors on Science and Technology, 2010). These projects must have the potential to create a breakthrough in learning and teaching (President's Council of Advisors on Science and Technology, 2010).

The Common Core State Standards (CCSS). The CCSS are a "set of high quality academic expectations in English-language arts and mathematics that define the knowledge and skills all students should master by the end of each grade level in order to be on track for success in college and career" (Missouri Department of Elementary and Secondary Education [MODESE], 2014, para. 1).

The National Assessment of Educational Progress (NAEP). The NAEP "is the largest nationally representative and continuing assessment of what America's students know and can do in various subject areas" (National Assessment Governing Board, 2014, p. 1).

The National Science Education Standards (NSES). These standards "outline what students need to know, understand, and be able to do to be scientifically literate at different grade levels" (National Research Council, 2014, p. 2).

The National Science Foundation (NSF). The NSF is an independent federal agency created by Congress in 1950. The NSF is responsible for keeping the United States at the leading edge of discovery in all sciences (National Science Foundation, 2014).

The Next Generation Science Standards (NGSS). The NGSS were adopted by the National Science Teachers Association to help provide a high-quality science education (National Research Council, 2014).

P21. This organization is designed to "serve as a catalyst to position 21st readiness the center of U.S. K12 education by building collaborative partnerships among education, business, community and government leaders" (Partnership for 21st Century Skills, n.d., para. 1).

Limitations and Assumptions

The following limitations were identified in this study:

Sample demographics. When conducting a study, the presence of limitations should be considered. Limitations of a study are aspects of the study the researcher knows may influence the results, but he or she is not able to control (Fraenkel, Wallen, & Hyun, 2015). The demographics of elementary STEM school principals and teachers, in addition to leaders of professional STEM organizations who responded to the interview, were a limitation of the study. The sample consisted of elementary principals and teachers from public school districts in the state of Missouri. The sample was limited due to the fact there are very few elementary STEM schools in Missouri. Therefore, the size of the survey sample was another limitation to the study. The results of this study might differ in other states with dissimilar demographics.

Instrument. The study involved original interview questions created by the researcher. The interviews were voluntary; therefore, the level and amount of participation were unpredictable. The participants' responses were self-perceptions of elementary STEM education, which may not reflect the opinions of other stakeholders.

Assumptions. The following assumption was accepted:

1. The responses of the participants were offered honestly and without bias.

Summary

This study involved the examination of the perspectives of STEM schools. Researchers have defined STEM education as follows:

> 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. (Tsupros, Kohler, & Hallinen, 2009, para. 4)

Science, technology, engineering, and mathematics education centers on the continued apprehension the United States is not adequately preparing students and teachers to enter into STEM-related fields (Gerlach, 2012). As a result, business leaders cannot find the talent needed to stay competitive (Gerlach, 2012).

In Chapter One, the background of the study was examined, and a historical basis for the research was provided. The interpretivism perspective framework was clarified, stating the belief one can "assume that the world is not simply out there to be discovered, but an ongoing story told and refashioned by particular individuals, groups, and cultures involved" (Butin, 2010, p. 60). The statement of the problem, the purpose of the study, and the research questions were also introduced.

In Chapter Two, a literature review is included to generalize STEM education. The main topics of discussion are to define the term STEM, to examine why there is the push for STEM education, and to present the reasons behind it. Chapter Three contains a detailed description of the methodology utilized throughout this study. Chapter Four includes a review of the sample data. The qualitative data collected from interviews are reviewed and analyzed. Chapter Four concludes with tables and figures to display the data. A summary of findings, implications for practice, and conclusions regarding the perceptions of elementary STEM schools are reported in Chapter Five.

Chapter Two: Review of Literature

Science, technology, engineering, and mathematics (STEM) education is vital to the future and offers students a broad range of basic skills and learning strategies to succeed (Robinson, 2014). In order for the United States to maintain global leadership and a competitive rank among all nations, students must be introduced to STEM opportunities to get them engaged in STEM education (Science Pioneers, n.d.). With more than three million job openings in STEM-related fields to be created by 2018, it is fundamental the United States strengthen the STEM education system (National Science Foundation, 2014). Results of the National Assessment of Educational Progress (NAEP) indicated less than "forty percent of students at every grade level tested, are proficient in math and science" (National Assessment Governing Board, 2014, para. 1). This statistic is proof math and science instruction need to be improved upon (National Assessment Governing Board, 2014).

This chapter includes a review of relevant literature surrounding STEM education. Furthermore, a framework is created for additional research and to provide depth and insight to better understand STEM education. The definition and historical overview of STEM education are provided in this chapter. Additionally, the goals, criteria, and obstacles to integrating a STEM education are explored. The push for STEM education in elementary schools, as well as student engagement and professional development for teachers in STEM education, are reviewed.

Theoretical Framework

Butin (2010) stated an interpretivism perspective "assumes that the world is not simply out there to be discovered, but an ongoing story told and refashioned by particular individuals, groups, and cultures involved" (p. 60). In addition, an interpretivist perspective "does not attempt to adjudicate between competing truth claims in order to determine the one best answer; rather interpretivism suggests that all one can do is accurately and thoroughly document the perspective being investigated" (Butin, 2010, p. 60). The ultimate goal of the theoretical framework of interpretivism is to understand the experiences of each individual (Taylor & Medina, 2013). This theory values individual experiences and gathers data through interviewing and then analyzing the documents (Lather, 2006). For this study, an interpretivism theoretical framework was utilized.

By using the interpretivism research perspective, the focus was on the perceptions of STEM schools as reported by elementary principals and teachers in STEM schools and the leaders of STEM organizations. According to Denzin and Lincoln (2003), this approach is not a focus on methods, but the researcher is to "watch, listen and record" (p. 119). Researchers have also stated the importance of the interpretivist theory in education since it allows one to understand not everything can be given a numerical value and statistics when working with people (Taylor & Medina, 2013). A STEM school focuses on the core subjects of science, technology, engineering, and mathematics. The process of STEM education is more than "simply incorporating these four subjects into a core curriculum" (Chen, 2011, p. 2). There must be "actual integration of these disciplines into a single meta-discipline" in order to be a successful and effective STEM school (Chen, 2011, p. 2).

The researcher, utilizing the interpretivist approach, sought to determine the perceptions of elementary principals and teachers in designated STEM schools and the viewpoints of leaders in STEM organizations. The criteria and/or best practices in order to be considered a STEM school were considered. Butin (2010) emphasized the key goal in the interpretivism theoretical framework is to "search for patterns of meaning" (p. 59). Therefore, the research in this study was focused on the perceptions of STEM education, utilizing interviews conducted with elementary principals and teachers in STEM schools, as well as the perceptions of leaders in STEM organizations.

What is STEM?

The acronym STEM stands for science, technology, engineering, and mathematics (Tsupros et al., 2009). A common definition is as follows:

> STEM education is an interdisciplinary approach to learning where rigorous academic concepts are couple 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. (Tsupros et al., 2009, para. 3)

The California Department of Education (2014) extended the definition of STEM education to include a sequence of courses or program of study that prepares students for the following:

> Successful employment, post secondary education, or both that require different and more technically sophisticated skills including application of mathematics and science skills and concepts; and to be competent, capable citizens in our technology-dependent, democratic society. (para. 1)

At the elementary level, STEM education provides an introduction to STEM as well as an awareness of STEM (California Department of Education, 2014). For middle school students, STEM allows students to begin the exploration of STEM-related careers (California Department of Education, 2014). Finally, for the high school, STEM prepares students for successful post-secondary education and beyond (California Department of Education, 2014).

To further analyze STEM education, the National Research Council (2014) separated the four STEM subjects as follows:

1. Science is the study of the natural world, including laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines.
2. Technology comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves.
3. Engineering is a body of knowledge about the design and creation of products and a process for solving problems. Engineering utilizes concepts in science and mathematics and technological tools.
4. Mathematics is the study of patterns and relationships among quantities, numbers, and shapes. Mathematics includes theoretical mathematics and applied mathematics. (p. 14)

Even though the words science, technology, engineering, and mathematics form the acronym STEM, the words combine to “represent a symbolic relationship among the four interwoven fields” (Basham & Marino, 2013, p. 9). Therefore, the four separate disciplines, science, technology, engineering, and mathematics, work together to form a cohesive unit of study (Basham & Marino, 2013).

A STEM curriculum is driven by problem-solving and exploratory learning, leading to the following definition:

> A standards-based, meta discipline residing at the school level where all teachers, especially science, technology, engineering, and mathematics teachers teach an integrated approach to teaching and learning, where discipline specific content is not divided, but addressed and treated as one dynamic, fluid study. (Brown, Brown, Reardon, & Merrill, 2011, p. 6)

The process of STEM education is more than merely incorporating the four subjects of science, technology, engineering, and mathematics into a curriculum. It is an actual integration of these four subjects into a single discipline of education (Chen, 2011). According to Gerlach (2012), the introduction of STEM revolved around the trepidation the United States was not preparing enough students, teachers, and practitioners in the STEM-related fields (Gerlach, 2012). In the increasingly innovative world market, these industries are in need of more workers (Gerlach, 2012).

Historical Overview of STEM Education

Since 2001, the acronym STEM has been a common part of the educational vocabulary (Fioriello, 2014). Judith A. Ramaley, the former director of the National Science Foundation's education and human-resources division, is responsible for starting the STEM program (Fioriello, 2014). However, STEM education dates back to at least the first State of the Union address by President George Washington, where he stated, "Nor am I less persuaded that you will agree with me in opinion that there is nothing which can better deserve your patronage than the promotion of science and literature" (as cited in Gonzalez & Kuenzi, 2012, p. 1). This provides evidence STEM education has been in the minds of educators and leaders for decades (Gonzalez & Kuenzi, 2012).

President Harry S. Truman signed the National Science Foundation Act in 1950. The purpose of this act was to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes" (National Science Foundation, 2014, para. 2). With this act, the National Science Foundation began creating funding and grants to support science education (National Science Foundation, 2014).

In 1957, the Soviet Union launched the Sputnik satellite, which provided a crucial crossroads for STEM education in the United States (Woodruff, 2013). This created a focus on science and technology education as a result of the fear of the United States falling behind other countries (Woodruff, 2013). The next turning point for STEM education was the creation of standards by the National Science Foundation, the National Council of Teachers of Mathematics, and the International Technology and Engineering Educators Association (Woodruff, 2013). All these organizations constructed guidelines to be implemented in the classroom (Woodruff, 2013).

In 2007, the National Academies published the report, *Rising Above the Gathering Storm: Engineering and Employing America for a Brighter Economic Future*, prompting an intensification of congressional interest regarding STEM education (Gonzales & Kuenzi, 2012). It also "warned of a threat to national prosperity and power" (Gonzales & Kuenzi, 2012, p. 2). This report led to the America COMPETES Act, which authorized STEM education programs (Gonzales & Kuenzi, 2012).

The focus on STEM continued in 2009 when President Barack Obama introduced the Educate to Innovate initiative (Federal Inventory of STEM Education, 2011). This was designed to move the United States to become the world leader in science and math achievement (Federal Inventory of STEM Education, 2011). The priorities of this initiative include the following:

1. Building a CEO-led coalition to leverage the unique capacities of the private sector
2. Preparing 100,000 new and effective STEM teachers over the next decade
3. Showcasing and bolstering federal investment in STEM
4. Broadening participation to inspire a more diverse STEM talent pool. (Federal Inventory of STEM Education, 2011, para. 4)

America has already begun to step forward to meet the challenges outlined. There are numerous public-private partnerships connecting powers to inspire children to become inventors and innovators (The White House, 2013).

The future of STEM education is outlined in the report, *Prepare and Inspire: K-12 STEM Education for America's Future*, written by the President's Council of Advisors on Science and Technology in 2014. This report outlined the following recommendations for STEM education:

1. Support the current state-led movement for shared standards in Math and Science
2. Recruit and train 100,000 great STEM teachers over the next decade who are able to prepare and inspire students

3. Recognize and reward the top five percent of the nation's STEM teachers, by creating a STEM master teachers corps
4. Use technology to drive innovation, by creating an advanced research projects agency for education
5. Create opportunities for inspiration through individual and group experiences outside the classroom
6. Create 1,000 new STEM-focused schools over the next decade
7. Ensure strong and strategic national leadership. (President's Council of Advisors on Science and Technology, 2014, pp. 8-9)

The purpose of this report was to create steps and actions needed in order to ensure the United States is a leader in STEM education (President's Council of Advisors on Science and Technology, 2010).

Goals of STEM Education

The idea of a STEM school is not a new concept. The origins of STEM schools can be traced to the early 20th century (Navruz, Erdogan, Bicer, Capraro, & Capraro, 2014). According to the United States Department of Commerce, the growth of STEM-related jobs over the last 10 years was three times that of non-STEM fields (see Figure 1) (Royal, 2013). In addition, the United States Bureau of Labor Statistics reported 15 of the 20 fastest-growing workforce fields will require considerable math and science preparation (Chen, 2011).

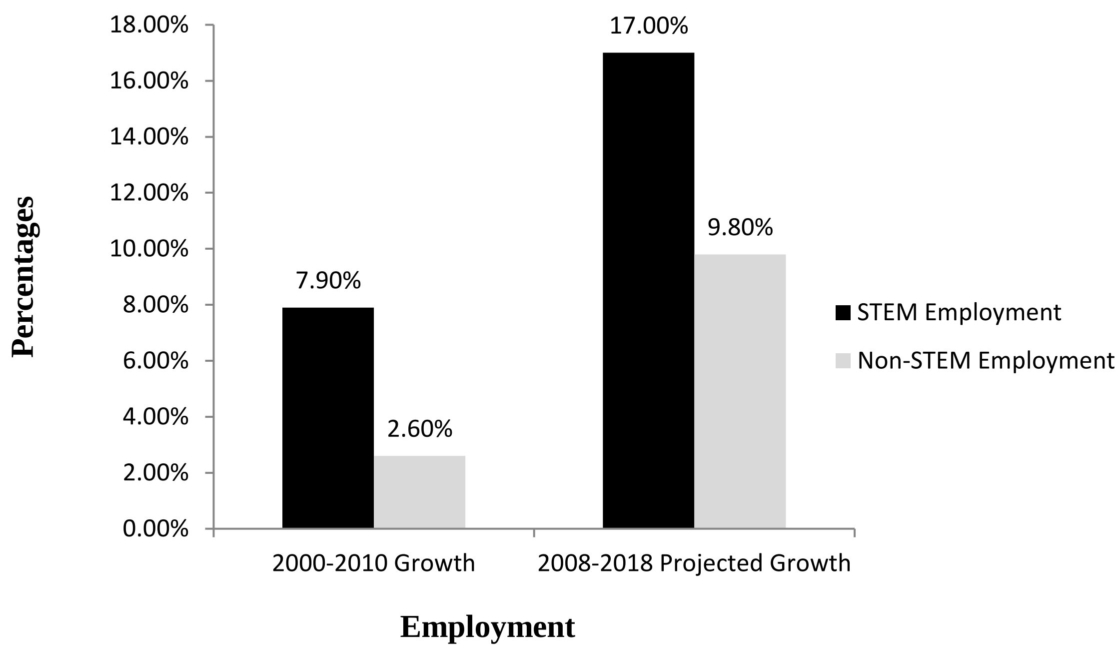

Figure 1. Recent and projected growth in STEM and non-STEM employment. A bar graph comparing STEM and non STEM job growth from 2000-2018. Adapted from "STEM: Good Jobs Now and for the Future," by D. Langdon, G. McKittrick, D. Beede, B. Khan, and M. Doms, 2011. Copyright 2011 by the U.S. Department of Commerce, Economics and Statistics Administration.

An education based on STEM teaches "independent innovation and allows students to explore greater depths of all the subjects by utilizing the skills learned" (Fioriello, 2014, para. 7). In the *International Journal of Global Education,* Bicer et al. (2014) noted there are three main goals for STEM education reported by the National Research Council. The first goal is to increase the "number of underrepresented students who pursue STEM majors in their post-secondary education in order to fill an increased portion of the prominent STEM-related job needs in the United States" (Bicer et al., 2014, p. 10). The second goal is to “expand the STEM-capable workforce and broaden the participation of women and minorities in that workforce” (Bicer et al., 2014, p. 10). Lastly, increasing STEM literacy and providing students with the necessary knowledge of basic mathematical and scientific concepts is a goal for improving STEM education (Bicer et al., 2014).

The overall goal of STEM is to increase the global competitiveness of the United States in the science, technology, engineering, and mathematics fields (Hanover Research, 2012). As cited in Hanover Research (2012), the President’s Council of Advisors on Science and Technology identified four major goals of STEM education:

1. Ensure a STEM-capable citizenry. This goal seeks to cultivate a citizenry that has “the knowledge, conceptual understandings, and critical-thinking skills that come from studying STEM subjects.” This is important even for those who never directly enter a STEM-related field.
2. Build a STEM-proficient workforce. This goal seeks to adequately prepare a sufficient number of workers for job openings in STEM-related careers which are expected to increase in coming years. Additionally, STEM-related skills are increasingly relevant in fields not directly related to STEM subjects. This goal seeks to adequately prepare a sufficient number of workers for job openings in STEM-related careers which are expected to increase in coming years. Additionally, STEM-related skills are increasingly relevant in fields not directly related to STEM subjects.
3. Cultivate future STEM experts. This goal aims to educate the best STEM experts in the world because they contribute “to economic growth, to

technological progress, to our understanding of ourselves and the universe, and to the reduction of hunger, disease, and poverty."

4. Close the achievement and participation gap. This goal aims to increase women and minority participation and interest in STEM fields in order to tap into the country's full potential. (p. 6)

These aims can be used to develop a set of practices intended to meet these four specific goals (Hanover Research, 2012).

The Push for STEM Education

There has been evidence of the push for increasing STEM education as early as 1983 from the report, *A Nation at Risk* (National Commission of Excellence in Education, 1983). This report stated, "Our nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world" (National Commission of Excellence in Education, 1983, para. 1). Over 30 years later, the United States still has anxieties about the condition of K-12 STEM education and not preparing an adequate amount of students, teachers, and experts in the STEM fields (Gerlach, 2012).

The United States Department of Education noted only 16% of high school students are interested in pursuing a STEM career and are considered proficient in mathematics (Hom, 2014). One of the major concerns of current K-12 STEM education is student performance on science and mathematics tests. As cited in Bicer et al. (2014), the NAEP results showed students were not skilled in mathematics and science. Furthermore, as shown in Figure 2, the United States did not execute well in mathematics and science when compared to other developed countries (Bicer et al., 2014).

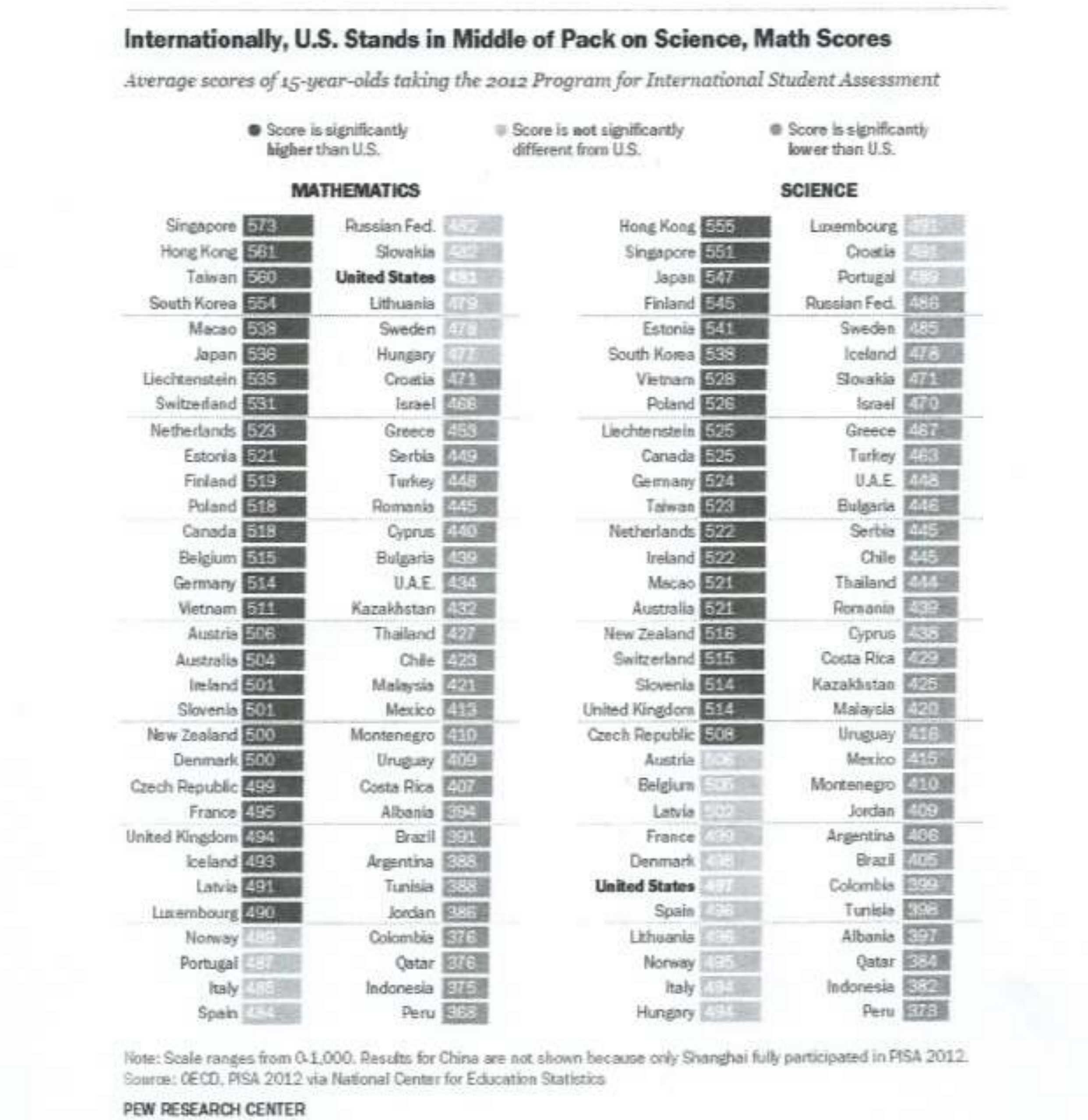

Figure 2. International rankings of math and science scores. Average scores of 15-year-olds taking the 2012 Program for International Student Assessment. Adapted from National Center for Education Statistics, 2015 (as cited in D. Desilver, 2015).

Yet another study by the Georgetown University Center on Education and the Workforce projected by "2018, 8.65 million workers will be needed in STEM-related jobs" (Hom, 2014, para. 6). The Committee on Integrated STEM Education, the National Academy of Engineering, and the National Research Council (2014) contended, "Education for students in science, technology, engineering, and mathematics has received increasing attention over the past decade which calls both for greater emphasis on these fields and for improvements in the quality of curricula and instruction" (p. 23). In order for effective K-12 STEM instruction to become the norm and what is expected, schools and districts must be transformed to ensure science, technology, engineering, and mathematics are given equal integration (Hom, 2014).

In an effort to create a clear and common vision for the future of STEM education, there has been and continues to be a national effort to improve at all levels of STEM education (Hom, 2014). The first initiative, *The Partnership for 21st Century Skills* (P21), has become a widely recognized model of instilling 21st century skills in the curriculum since it began in 2002 (Partnership for 21st Century Skills, 2009). The principal goal for P21 is to prepare students in the United States with the skills needed to compete in the global economy (Partnership for 21st Century Skills, 2009). The Framework for 21st Century Learning combines a "discrete focus on 21st century student outcomes with innovative support systems to help students master the multi-dimensional abilities required of them in the 21st century and beyond" (Partnership for 21st Century Skills, 2009, p. 1). The student outcomes include the following:

1. Core Subjects and 21st Century Themes
2. Learning and Innovation Skills
3. Information, Media, and Technology Skills
4. Life and Career Skills. (Partnership for 21st Century Skills, n.d., para. 2)

The essential support systems include the following:

1. 21st Century Standards
2. Assessment of 21st Century Skills
3. 21st Century Curriculum and Instruction
4. 21st Century Professional Development
5. 21st Century Learning Environments. (Partnership for 21st Century Skills, 2009, p. 1)

These outcomes and support systems which are available prove to be critical components necessary to ensure 21st century readiness for every student (Partnership for 21st Century Skills, 2009).

Another national-level effort to increase STEM education is the Obama Administration's Educate to Innovate campaign (Federal Inventory of STEM Education, 2011). This initiative was launched in 2009 as a way to get students inspired to excel in science, technology, engineering, and math subjects (The White House, 2013). President Obama also enlisted the efforts of leading companies, foundations, non-profits, and science engineering societies to assist in the nationwide effort to increase STEM awareness (The White House, 2013).

The most recent development in federal involvement with STEM education is President Obama's 2015 budget. This budget "invests $2.9 billion, an increase of 3.7 percent over 2014, in programs across the Federal Government on STEM education" (White House Office of Science and Technology Policy, 2014, para. 2). This budget focuses on the five key areas as identified by the Federal STEM Education Five-Year Plan:

1. K-12 Education – This includes improving STEM education in K-12 schools including excellent teachers, rigorous courses, and regional partnerships.
2. Undergraduate STEM Education – To increase the number of well-prepared graduates with STEM degrees.
3. Graduate Education – This entails preparing highly skilled scientists and engineers who will support American innovation.
4. Informal STEM Education – This will be done by giving more boys and girls engaging STEM experiences including the White House Science Fair.
5. Supporting Innovation and Next Generation Learning Technologies – This will allow the Department of Education to support high-risk, high-return research on next generation learning innovations and technologies. (White House Office of Science and Technology Policy, 2014, p. 3)

The Obama Administration strongly believes the United States must train more and more students to excel in science, technology, engineering, and mathematics (White House Office of Science and Technology Policy, 2014).

Project Lead the Way is the nation's leading contributor of K-12 STEM programs and "prepares students to be the next generation of problem solvers, critical thinkers, and innovators for the global economy" (Project Lead the Way, n.d., para. 1). Project Lead the Way offers state-of-the-art curriculum and high-quality teacher professional development to more than 6,500 K-12 schools in the United States (Bertram, 2014). Studies have shown the following:

> Over 93 percent of Project Lead the Way students intend to pursue at least a two-year or four-year degree after high school. Of the high school seniors taking

> Project Lead the Way courses, 70 percent intend to study engineering, technology, computer science, or another applied science. (Bertram, 2014, para. 6)

In Missouri, Governor Jay Nixon's spending plan includes $2 million in Project Lead the Way grants as part of an effort to increase STEM programs across the state of Missouri to 200 schools (Riley, 2015).

Benefits of STEM Education

The United States Secretary of Education has said, "Everyone has a stake in improving STEM education. Inspiring all our students to be capable in math and science will also help America prepare the next generation of STEM professionals—scientists, engineers, architects, and technology professionals—to ensure competitiveness" (Connections Learning, 2015, p. 2). Supporters say there is a need to draw more students into the STEM fields and to keep them engrossed in science, technology, engineering, and mathematics throughout their education careers (Yednak, 2015).

The long-term benefits of STEM include preparing students by providing them with meaningful curriculum that is relevant to today's society (Chen, 2011). Research also shows that an early STEM education teaches students independent innovation and helps to develop critical thinking skills (Chen, 2011). Over time, STEM has begun to receive support from government leaders, educators, business members, and students (Chen, 2011). In addition, STEM graduates have a better potential to find a job with a good salary right out of school (Chen, 2011).

In June of 2015, author Waldron cited the following as the top 15 benefits of a STEM education:

1. It helps you stay current

2. It allows you to be innovative
3. You can make a difference
4. It helps you succeed with the Arts
5. Cosmetics industry is huge
6. Promotes equality education
7. Prepares for college curriculum
8. Can land you a better job within the fashion industry
9. Confidence booster
10. Gives you a higher income
11. Better chance at landing a job
12. Great for writers
13. Growing field
14. Shapes a better world
15. Part of our daily lives. (para. 2)

For the United States, the greatest benefit of STEM is to ensure this country continues to compete globally, create jobs, and achieve economic growth (Chen, 2011).

Elementary STEM Education

Science, technology, engineering, and mathematics education initiatives are numerous, including the Next Generation Science Standards (NGSS) and Common Core State Standards (CCSS), which both emphasize the integration of STEM subject areas (Woodruff, 2013). However, the majority of STEM integration is focused toward the high school and collegiate levels (Lynch, Han, Peters, & House, 2013). Chesloff (2013) stated, “Like STEM, investment in early-childhood education is a workforce-pipeline issue" (para. 12). Research has shown "high-quality learning environments provide children with a structure in which to build upon their natural inclination to explore, build and to question" (Chesloff, 2013, para. 12). In addition, "Early learning experiences can contribute to positive academic trajectories in STEM fields, thus a concentration in STEM at an early age can encourage children to believe they can succeed in STEM domains" (Ricks, 2012, p. 43). Researchers confirmed the brain is exceptionally alert to learning math and logic from the ages of one to four (Chesloff, 2013).

Research has shown kids who experience STEM education early through hands-on learning are the students best equipped to develop and maintain a greater understanding of STEM concepts as they get older and progress through school (Wheelcock College Aspire Institute, 2010). By introducing STEM in grades PreK-6, it will help ensure a foundation of the knowledge and skills necessary to become successful in the STEM workforce (Wheelcock College Aspire Institute, 2010). In addition, educators feel STEM instruction in the early years of school can "boost overall learning, by tapping into children's natural curiosity and interest in experimentation and engineering" (Wheelcock College Aspire Institute, 2010, p. 9). However, this will require school districts to shift from the current method of instructional time focused on literacy and math to provide a greater emphasis on STEM subjects including science, technology, and engineering (Wheelcock College Aspire Institute, 2010).

At the elementary level, STEM education focuses on introductory-level STEM courses, as well as creating an awareness of the STEM field and possible occupations (Hom, 2014). The goal of STEM at this level is to create and pique the students' interest to choose STEM courses instead of feeling as though they are required to, without a choice (Hom, 2014). A high-quality learning environment will help provide young students with a structure where they can build upon their natural disposition to explore, build, and question (Chesloff, 2013).

Criteria for a STEM School

In order to have a successful integration of STEM education, there are several characteristics that must be implemented (Carnegie Science Center, 2014). A STEM education will be successful when the four major features of STEM education, as reported by the Carnegie Science Center (2014), are met. Those four features include STEM being "collaborative, hands-on, problem-solving, and project-based" (Carnegie Science Center, 2014, p. 15). A collaborative learning approach for students closely resembles the real-world setting which students will encounter in future careers (Carnegie Science Center, 2014). Teachers must also collaborate and teach together to provide benefits of different perspectives (Carnegie Science Center, 2014).

A hands-on STEM education offers students a plethora of ways to explore science, technology, engineering, and mathematics (Carnegie Science Center, 2014). This leads to more student engagement when compared to simply memorizing and taking tests (Carnegie Science Center, 2014). The problem-solving aspect of STEM education refers to presenting students with a challenge and requiring them to figure out how to solve that particular challenge (Carnegie Science Center, 2014). Finally, project-based learning involves providing instructions to complete a project (Carnegie Science Center, 2014). In addition to these four main features, STEM "should start early, businesses would be involved, STEM extracurricular activities would be offered, and teachers would integrate STEM within the state standards" (Carnegie Science Center, 2014, p. 17). As a result, the ultimate goal of STEM education is to develop the next generation of collaborative problem solvers (Carnegie Science Center, 2014).

Another report, completed by Hanover Research (2012), stated best practices in elementary STEM programs include "instructional techniques, curriculum and programs, out-of-class activities, the importance of highly-qualified teachers, and long-term program sustainability" (p. 10). Some common instructional techniques often used in STEM schools include "traditional teacher-led instruction, project-based learning, workplace or lab-based learning, and the use of technology-supported learning tools" (Hanover Research, 2012, p. 10). A standards-based curriculum has also been shown to be essential for a successful STEM education (Hanover Research, 2012). This is evidenced by the acceptance of the CCSS, which emphasize depth of knowledge in mathematics and science (Hanover Research, 2012). Highly qualified STEM teachers are crucial for STEM education (Hanover Research, 2012). Out-of-class activities also play a significant role in cultivating a STEM interest in students (Hanover Research, 2012). These activities may include summer programs, after-school enrichment activities, and science fairs (Hanover Research, 2012).

Curriculum and Standards

When comparing the K-12 curriculum of the United States to international curriculums, studies indicate major differences. Other countries are shown to have a set of "uniform national curriculum standards, which detail the content to be covered by each grade level" (STEM Smart, 2014, p. 2). This focused curriculum then facilitates the learning occurring in STEM subjects (STEM Smart, 2014).

However, educators are finding hope in the adoption of the CCSS that will provide a framework for school districts to follow (STEM Smart, 2014). The development of the National Research Council's Framework for K-12 Science Education is also establishing national guidelines to help states develop science curricula (STEM Smart, 2014). These national guidelines will allow school districts nationwide to focus on important topics logically sequenced over time and to ensure a deeper understanding (STEM Smart, 2014).

The Compendium of Best Practice K-12 STEM Education Program identifies highly effective elementary STEM programs (Hanover Research, 2012). In order to be selected as highly effective, programs must meet the following four criteria:

1. Challenging Content and Curriculum which is inquiry-based, experiential, and clearly defined.
2. An Inquiry Learning Environment where teachers and students work together as active learners.
3. Defined Outcomes and Assessment where goals are clearly defined and success is measured against them.
4. Sustained Commitment and Community Support with strong Leadership and sufficient resources. (Hanover Research, 2012, p. 13)

Research has indicated that a "coherent and rigorous curriculum" is crucial for a STEM initiative in any school to be successful (Hanover Research, 2012, p. 12). Those in support of STEM education advocate STEM is the "interrelated nature of all the STEM subjects and the necessity of implementing an interdisciplinary approach rather than treating the individual subjects as stand-alone subjects" (Hanover Research, 2012, p. 8).

Herschbach (2011) reported there is not a specific curriculum model that represents STEM; instead, there are numerous ways to explain STEM education. Besides, "practically any kind of educational intervention that is even remotely associated with science, technology, engineering, or mathematics is referred to as STEM innovation" (Herschbach, 2011, p. 98). As a result, this lack of definition could be what threatens the integration and movement of STEM education (Herschbach, 2011). Herschbach (2011) continued by implying STEM education is an integrated curriculum design to apply the content learned across all the disciplines in STEM. According to Herschbach (2011), an integrated curriculum can be organized in two fields: correlated or broad.

The correlated curriculum is the most popular, in which each subject area maintains its separate identity (Herschbach, 2011). This approach fits most easily into current instructional practices in schools (Herschbach, 2011). In the broad field pattern of STEM education, "A cluster of related but different subjects is organized into a single area of study" (Herschbach, 2011, p. 101). An example of this would be a general science course including units from other sciences such as biology, physics, and chemistry (Herschbach, 2011).

Student Achievement and STEM

It is not easy to define or measure student achievement (Cunningham, 2012). Student achievement can be defined as "a measure of the amount of academic content a student learns in a determined amount of time" (Cunningham, 2012, p. 1). Achievement for students is typically measured by performance on standardized assessments in the areas of reading, language arts, math, science, and history (Cunningham, 2012).

Despite the increase in popularity of STEM education, there has been little research documented to determine the effects a STEM education has on academic achievement (Becker & Park, 2011). One meta-analysis study indicated, “Integrative approaches among STEM subjects have positive effects on the students’ learning (Becker & Park, 2011, p. 23). However, researchers have stated future research needs to be done to consider the effects of STEM education (Becker & Park, 2011).

Another study was conducted by Bicer et al. (2014) to examine performance on mathematics tests in Texas. Students attending STEM schools were compared to students of the same grade in non-STEM schools (Bicer et al., 2014). Researchers found students attending the STEM academies “performed slightly better in mathematics than their peers in non-STEM schools” (Bicer et al., 2014, p. 16). The test scores examined were state-based performance tests all students in Texas are required to take each year in high school (Bicer et al., 2014).

Professional Development and STEM Schools

With many states incorporating STEM education in schools, the significance of professional development for elementary teachers involved in STEM education is a topic in which interest is growing (Shapiro, 2012). Professional development is defined as “a comprehensive, sustained, and intensive approach to improving teachers’ and principals’ effectiveness in raising student achievement” (National Staff Development Council, n.d., figure 34). In the 2015 budget, the President of the United States included investments to improve STEM education, including “preparing 100,000 excellent STEM teachers over the next decade” (White House Office of Science and Technology Policy, 2014, p. 2).

As a result, there is a proposed $40 million in the 2015 budget to support evidence-based STEM teacher programs to recruit and train effective STEM teachers (White House Office of Science and Technology Policy, 2014). This budget also included $20 million to launch the STEM Master Teacher Corps, which will provide top-performing math and science teachers as a national resource to observe and learn best practices (White House Office of Science and Technology Policy, 2014).

Based upon research, Hanover Research (2012) fashioned a list to highlight the most applicable STEM teacher development techniques:

- Active – Engage teachers in practicing concrete tasks related to teaching, assessment, and observation of learning.
- Collaborative – Include time for teachers to share ideas and practices.
- Learner-centered – Draw upon teachers' questions, inquiry, and experiences.
- Student-centered – Build on teacher's current work with students.
- Relevant – Address problems teachers experience in their classrooms.
- Content-specific – Develop teacher's knowledge and capacity to teach specific subject matter.
- Pedagogy Focused – Provide modeling, coaching, and problem solving around specific areas of practice.
- Appropriately Structured – Plan a sufficient amount of time for teachers to participate in and process their professional development. (p. 19)

In order to enhance student knowledge of STEM, there is a need to enhance teachers' ability to teach STEM (Nadelson, Seifert, Moll, & Coats, 2012). Furthermore, "Enhancing the quality and quantity of K-12 STEM education is inextricably linked to the continued professional development of K-12 teachers" (Nadelson et al., 2012, p. 69). In addition, Nadelson et al. (2012) asserted, "The link between teachers' comfort, their motivation to teach, and student learning in STEM provides good reason for attending to comfort and related variables in professional development directed at enhancing teacher capacity to teach STEM content and curriculum" (p. 70). Professional development is an often-used strategy by schools and educators to continue strengthening practice throughout careers (Nadelson et al., 2012).

Finally, for professional development to provide the maximum impact, it must be implemented over an extended period of time (Fisher, Frey, & Pumpian, 2012). There are a number of STEM professional development programs including the National Center for Technology Literacy, the National Center for STEM Elementary Education, and even the Mickelson ExxonMobil Teachers Academy (Hanover Research, 2012). Fisher et al. (2012) acknowledged, "A culture committed to student learning must be equally committed to the learning of teachers" (p. 163). Given teachers have a direct influence over student learning, it is vital to deliver teachers the necessary resources so they may provide the best quality STEM education for students (Avery & Reeve, 2013).

Student Engagement and STEM

Student engagement can be defined as "the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught" (The Glossary of Education Reform, 2014, para. 1). The topic of student engagement continues to grow in popularity, and as a result, it may be discussed in several different ways (The Glossary of Education Reform, 2014). These include intellectual engagement, emotional engagement, behavioral engagement, physical engagement, and social engagement (The Glossary of Education Reform, 2014).

Intellectual engagement means to design lessons or projects that cater to student interests or incite curiosity (The Glossary of Education Reform, 2014). Emotional engagement involves promoting positive emotions in students that will enable the learning process (The Glossary of Education Reform, 2014). Behavioral engagement introduces variation into the classroom routine, which can reduce the potential disengagement that can occur when students are doing the same things continuously (The Glossary of Education Reform, 2014). The use of physical activity or kinesthetic learning provides physical engagement for students (The Glossary of Education Reform, 2014). Social engagement is achieved through having students work with a partner or in a group (The Glossary of Education Reform, 2014).

In order to foster student engagement, Marzano (2013) advocated teachers should ask themselves four questions which incorporate these previously mentioned types of engagement:

1. Do I provide a safe, caring, and energetic environment?
2. Do I make things interesting?
3. Do I demonstrate why the content is important?
4. Do I help students realize that personal effort is key to success? (p. 82)

Today, STEM means facilitating learning environments that will allow students to be more active (Royal, 2013). By doing this, students become engaged in their own learning (Royal, 2013). Students who are actively engaged in their learning better remember what they have learned (Royal, 2013).

There are four tips Goldston (2014) offered teachers to help them connect with all students:

1. Use student input and interests to facilitate learning.
2. Encourage students to articulate individual questions and concerns.
3. Offer optional challenges once a student has completed their work.
4. Prioritize your own engagement. (para. 4)

Researchers in STEM education have found several key factors which are important in providing an effective, engaging STEM education. First, "It capitalizes on students' early interests and builds on what they know, and provides opportunities to engage in the practices of science and mathematics to sustain their interests" (STEM Smart, 2014, p. 2). It is important for educators to recognize the challenge of confirming instruction not only covers the most important science and math content, but can engage even bored, distracted, unmotivated students (STEM Smart, 2014).

Obstacles in a STEM Education

In a study conducted by the Carnegie Science Center (2014), five major obstacles to STEM education were found. The first obstacle involves the misperceptions of parents and the public (Carnegie Science Center, 2014). The common misperceptions include the following: "STEM is only for smart students, only the college-bound student benefits from STEM, and STEM is about math and science and therefore not for girls" (Carnegie Science Center, 2014, p. 39). Hence, parents and the public must be educated properly on what STEM is and that it is for everyone, no matter the academic level, socioeconomic status, or gender (Carnegie Science Center, 2014).

The second major obstacle to STEM education includes the misperceptions held by teachers (Carnegie Science Center, 2014). Many teachers feel STEM requires a lot of training, and the certification process is difficult (Carnegie Science Center, 2014). Teachers also feel STEM is too hard to teach and is too difficult to fit into the core curriculum (Carnegie Science Center, 2014). Finally, teachers perceive STEM to be cost-prohibitive to implement (Carnegie Science Center, 2014).

The next obstacle presents issues inside the classroom. Oftentimes, older teachers are not motivated to embrace STEM and simply tend to teach to the test (Carnegie Science Center, 2014). Furthermore, teachers feel they lack the time to incorporate STEM into their classrooms (Carnegie Science Center, 2014). Finally, teachers lack the experience necessary to implement STEM, and often, students are unprepared to take STEM classes (Carnegie Science Center, 2014).

The fourth obstacle includes issues outside of the classroom, such as lack of education funds (Carnegie Science Center, 2014). With budget cuts, school districts have been forced to cut back programs (Carnegie Science Center, 2014). The lack of STEM curriculum available also presents problems with trying to integrate a STEM education (Carnegie Science Center, 2014).

The final obstacle for STEM education, as reported by the Carnegie Science Center (2014), includes matters outside of the school. The first part of this obstacle includes a lack of communication and collaboration with colleges and universities (Carnegie Science Center, 2014). This is a significant issue due to the fact many schools lack access to STEM curriculum (Carnegie Science Center, 2014). The lack of extracurricular activities that support STEM is another facet of external obstacles to the integration of STEM education (Carnegie Science Center, 2014).

Summary

In this chapter, the parameters surrounding STEM education were reviewed and presented. The definition of STEM and historical overview were provided. This was followed by the goals, criteria, curriculum, and obstacles in the implementation of a STEM education. The push for STEM education at the elementary level, as well as student engagement and professional development for teachers, were topics included in this review. The theories, authors, and studies reviewed in the literature suggested there is a need to continue the development of STEM education in school communities and to further developments around this topic.

In Chapter Three, the methodology and research design are detailed. The population and sample, instrumentation, data collection, data analysis, and ethical considerations are also presented. Chapter Four includes a review of the sample data. The qualitative data collected from interviews are reviewed and analyzed. Chapter Four concludes with tables and figures to display the data. A summary of findings, implications for practice, and conclusions regarding the perceptions of elementary STEM schools are reported in Chapter Five.

Chapter Three: Methodology

Science, technology, engineering, and mathematics education is crucial in the preparation of today's high-tech information economy (Drew, 2011). Science, technology, engineering, and mathematics education is accountable for providing the United States with three different kinds of academic capital:

1. Scientists and engineers who will continue the research and development that is central to the economic growth of our country
2. Technology proficient workers who are capable of dealing with the demands of a science-based, high technology workforce
3. Scientifically literate voters and citizens who make intelligent decisions about public policy and understand the world around them. (Federal Inventory of STEM Education, 2011, para. 5)

The importance of STEM education is evident from this list. In order for the United States to remain competitive in the science, technology, engineering, and math fields, STEM education must motivate and inspire students to pursue STEM programs (Hom, 2014).

In this chapter, the research questions are restated. The population and sample size for the study are discussed. Interviews were conducted with elementary principals from schools that have integrated a STEM education approach regarding the STEM education process. In addition, a separate set of interview questions were created for teachers in the same STEM-integrated schools. Finally, professional STEM organization leaders were interviewed to gain insight on the organization's philosophies and stance on STEM education. Data collection procedures are documented. In the data analysis section, a discussion is included as to how the data were organized and analyzed after the collection and the application of statistical research tools. To conclude, ethical considerations are considered to ensure understanding of the process used to protect the identity of the districts, schools, and participants in the study.

Problem and Purpose Overview

One of the most-requested curriculum designs for K-12 education in the United States is STEM education (Meyrick, 2012). In a speech at the National Academies of Science in 2010, President Barack Obama stated:

> Reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation is essential to meeting the challenges of this century. That's why I am committed to making the improvement of education over the next decade a national priority. (as cited in Eberle, 2010, para. 9)

The Obama Administration has continued to stand committed to providing students at every level, elementary through post-secondary, with the necessary skills to excel in the fields of science, technology, engineering, and math (The White House, 2013).

The purpose of this study was to determine perceptions of STEM schools from a variety of stakeholder viewpoints. In 2012 Meyrick contended, "Emergence of STEM curriculum in the public K-12 educational system provides opportunities for all level-learners to master skills and content important for the 21st century learning" (p. 4). The desire to keep the United States as the frontrunner in research, innovation, and technology came to the forefront with the publication of *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future* (Lantz, 2009). This publication created an awareness of the lack of scientists, engineers, and mathematicians needed for the United States to remain competitive (Lantz, 2009).

Research questions and hypotheses. The following research questions guided the study:

1. What are the perceptions of elementary principals in STEM schools regarding teacher attitude toward the implementation of STEM?

2. What are the perceptions of teachers in STEM schools regarding student engagement?

3. What are the perceptions of teachers in elementary STEM schools regarding professional development?

4. What are the perceptions of professional STEM organizations, elementary principals, and elementary teachers regarding the benefits of elementary STEM schools?

Research Design

This qualitative study was designed to allow for analysis of the perceptions of STEM schools among elementary principals, teachers, and the leaders of professional STEM organizations. The primary data source for this study was interviews conducted with STEM school elementary principals, STEM school teachers, and leaders of STEM organizations. The interviews were conducted with four elementary principals and six teachers in different public school districts in Missouri that function as STEM schools to gain insight on the effectiveness of STEM schools. Interviews were conducted with three leaders of professional STEM organizations.

The participants interviewed were given the opportunity to offer their personal opinions in regards to the overall effectiveness of STEM education. Interviews were conducted at a time and place convenient for the participants. The researcher utilized interview questions specific for each group – principals, teachers, and STEM organization leaders.

Population and Sample

The population consisted of professionals in the STEM community. A purposive, or judgmental, sampling technique was utilized (Bluman, 2015). This sampling method was chosen due to the fact participants were selected because of their involvement in STEM. Elementary principals and teachers were selected from the participating STEM schools. Schools were selected on the basis of geographical location to include the major cities across Missouri and the willingness of the schools' educators to participate in the project. Geographical locations are shown in Table 1. The researcher contacted elementary STEM schools in Missouri to acquire principal and teacher interviews.

The Missouri Department of Elementary and Secondary Education (MODESE) website provided information about these STEM schools. In addition, professional STEM organizations in Missouri were contacted for potential interviews. These organizations were chosen based on geographical location to include the major cities across the state of Missouri. The directors of professional STEM organizations included the Missouri STEM Director with the MODESE, Project Lead the Way, and STEM Teacher Quality in St. Louis Education.

Table 1

Interview Participants

Participant	Geographical Location
STEM Leader A	St. Louis
STEM Leader B	Jefferson City
STEM Leader C	Rolla
Principal A	Nixa
Principal B	St. Louis
Principal C	Columbia
Principal D	Kansas City
Teacher A	Nixa
Teacher B	Nixa
Teacher C	Columbia
Teacher D	Columbia
Teacher E	Kansas City
Teacher F	Kansas City

Note. Geographical locations are listed for each person interviewed.

Instrumentation

Interview questions (see Appendices A, B, and C) were created by the researcher to gain perceptions of elementary principals, elementary teachers, and leaders of professional STEM organizations. The questions were created based upon the conceptual framework of the interpretivism perspective. The interview questions were field-tested by certified personnel within the public school system. Then, interviews were conducted to gain a better understanding of STEM schools and to examine the perceptions of elementary school principals, teachers, and leaders of professional STEM organizations about the effectiveness of STEM schools.

Each participant completing an interview was provided a letter of introduction (see Appendix D), a letter of informed consent (see Appendix E), and an advance copy of the questions prior to the interview.

Data Collection

Approval was received by the Lindenwood IRB before any potential participants were contacted (see Appendix F). All participants were contacted by telephone and/or electronic communication and informed of the research. After communicating interest in participating in the study, each participant was presented, via electronic communication, with an informed consent form and a copy of the interview questions. Interview schedules were established and confirmed.

Interviews were conducted face-to-face or over the telephone. The interview data were audio recorded, with the permission of each participant, for the purpose of transcribing the responses accurately. The recordings were uploaded and saved to the researcher's password-protected computer. A qualified third-party transcriptionist service was used to transcribe the recorded interviews into a Microsoft Word document. A copy of each transcript was emailed to the researcher from the transcriptionist and stored on the researcher's personal computer. All electronic data were stored and secured on a password-protected computer.

The researcher randomly checked the transcript against the recorded interviews to ensure accuracy. Each participant was referred to by a code throughout the study to respect confidentiality and anonymity of those involved in the study. After the conclusion of the study, all data will be retained for three years according to the federal regulations. Once the three years have passed, all electronic data will be deleted and no longer available. All paper records will be shredded and disposed.

Data Analysis

At the conclusion of the interviews, the transcripts were reviewed, interpreted, and organized. According to Gay, Mills, and Airasian (2011), an interview is "a purposeful interaction in which one person is trying to obtain information from another" (p. 418). In this study, a qualitative approach was used to construct meaning by identifying patterns and themes that were developed during data analysis (Gay et al., 2011). Gay et al. (2011) also stated the qualitative data analysis process focuses on the following:

> (1) becoming familiar with the data and identifying potential themes in it;
> (2) examining the data in depth to provide detailed descriptions of the setting, participants, and activity; and
> (3) categorizing and coding pieces of data and grouping them into themes.
> (p. 469)

The coding of the qualitative data was also employed. This refers to categorically marking units of text with codes and/or labels as a way to indicate patterns and meaning (Gay et al., 2011).

Ethical Considerations

Upon approval of the Lindenwood University Institutional Review Board, research began. All information concerning the interview participants collected was secure and confidential. Data codes were assigned to each participant to further ensure confidentiality and anonymity. All documents were kept in a secure location under the supervision of the researcher.

Summary

This qualitative study involved elementary school principals and teachers of STEM schools and three leaders of professional STEM organizations in Missouri. Qualitative data were collected through interviews with the participants, and questions revolved around perceptions of STEM education. The responses to the interview questions were transcribed and coded to reveal categories and themes.

In Chapter Three, the methodology used in this qualitative study was described. An overview of the problem and purpose of the study was presented. Descriptions of the population and sample were provided, as well as the instrumentation used. Finally, the data collection and data analysis processes were detailed. Chapter Four includes a review of the sample data. The qualitative data collected from interviews are reviewed and analyzed. Chapter Four concludes with tables and figures to display the data. A summary of findings, implications for practice, and conclusions regarding the perceptions of elementary STEM schools are reported in Chapter Five.

Chapter Four: Analysis of Data

The purpose of this study was to determine the perceptions of elementary principals, teachers, and professional STEM organization leaders on STEM schools regarding teacher attitude, student engagement, professional development, and the benefits of STEM. It is estimated by the website STEMconnector.org that by 2018, 8.65 million workers will be needed in STEM-related jobs (as cited in Hom, 2014). The Committee on Integrated STEM Education, The National Academy of Engineering, and The National Research Council (2014) contended, “Education for students in science, technology, engineering, and mathematics has received increasing attention over the past decade which calls both for greater emphasis on these fields and for improvements in the quality of curricula and instruction” (p. 21).

The concern to keep the United States as the frontrunner in research, innovation, and technology came to forefront with the publication of *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future* (Gonzalez & Kuenzi, 2012). This publication created an awareness of the lack of scientists, engineers, and mathematicians for the United States to remain competitive (Gonzalez & Kuenzi, 2012).

As stated in previous chapters, four research questions guided this study:

1. What are the perceptions of elementary principals in STEM schools regarding teacher attitude toward the implementation of STEM?

2. What are the perceptions of teachers in STEM schools regarding student engagement?

3. What are the perceptions of teachers in elementary STEM schools regarding professional development?

4. What are the perceptions of professional STEM organizations, elementary principals, and elementary teachers regarding the benefits of elementary STEM schools?

Qualitative data were gathered through phone interviews and face-to-face interviews with a variety of individuals associated with the STEM community. The participants interviewed for the study represented school districts and organizations from the St. Louis, Kansas City, and central Missouri areas. The individuals participating were divided into three categories which included elementary STEM school principals, elementary STEM school teachers, and leaders of professional STEM organizations.

Interviews

Leaders from professional STEM organizations. To assure anonymity, each STEM leader was assigned a data code. For example, the first STEM leader interviewed was referred to as STEM Leader A, and the second STEM leader interviewed was referred to as STEM Leader B throughout the interview portion.

Interview question 1. How do you define STEM education in elementary schools?

The three STEM leaders interviewed were consistent with their definitions of STEM education. Although, due to the subjectivity of STEM, one single definition of STEM education does not exist. However, according to Tsupros et al. (2009), a common definition is as follows:

> STEM education is an interdisciplinary approach to learning where rigorous academic concepts are couple 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. (para. 3)

All the STEM leaders interviewed provided definitions consistent with Tsupros et al. (2009).

The only STEM organization leader to refer to the abbreviation of the four distinct content areas: science, technology, engineering, and math was STEM Leader A. She also stated STEM is "bringing that content alive by making real world connections, cultural connections, career connections, connections to student interest, that allow them to see themselves as current and future STEM workers." In addition, STEM Leader A noted each of the areas of STEM have distinct content standards that the elementary teacher would need to follow. In agreement, STEM Leader B felt STEM involves a connection between education and the real world or workforce.

According to STEM Leader B, STEM is "not a collection of towers, but it is more of a process." He went on to state STEM is a process of "helping students to be able to not only function in school, but to function outside of school in their future, so it's a process of being able to utilize what they are learning." In addition, STEM Leader B was adamant that STEM starting in kindergarten is a process of integration of subject matter and the real world.

Interview question 2. Why is elementary STEM education important to the United States?

Both STEM Leaders B and C were in agreement that in the United States, by the time students are in second or third grade, students have made their minds up about whether or not they like math or science. To continue, STEM Leader C stated STEM education provides these students with a “better chance to see science and mathematics in action in the process before they get turned off to it.” He also stated the importance of getting the chance to see, feel, and touch science and math rather than simply learning it out of a book. To conclude, STEM Leader B added that in order to help students see how the integration of science, technology, engineering, and mathematics works, educators have to start at an early age to enable students to recognize they can excel in math and science.

As shown in the results on Table 2, the only leader to mention the importance of STEM and the future workforce was STEM Leader A. She explained, “the Department of Defense has in their strategic plan that the diversity of STEM workers is considered to be a national security interest because we need all of the creative minds possible.” She also put into focus the importance of teaching students STEM is for everyone, not just certain kinds of people. She added that corporations are currently funding STEM initiatives at the elementary level because of the realization:

> If kids don’t see themselves as STEM capable and self-select away from some of the options available in high school, not to mention in college, then we are actually not frontloading the workforce with young people that could bring benefit to us.

She ended with saying the sooner recognition that STEM is everywhere occurs, there is more likely a chance of diversifying the STEM workforce.

Table 2

Reasons Elementary STEM Education is Important to the United States

Participant	Response
STEM Leader C	Better chance to see math and science in action
STEM Leader C	Ability to see, touch, and feel science and math
STEM Leader A	Diversifying the STEM work-force
STEM Leader B	Students recognize they can excel in math and science

Note. Column one indicates the STEM leader interviewed and corresponds to column two with the response. Participants were asked why elementary STEM education is important to the United States.

Interview question 3. What are the challenges we as a nation face with regards to STEM education?

As shown in Table 3, all three STEM leaders interviewed agreed one of the challenges STEM education faces is community and parental perception of what STEM is. They all felt people do not understand what STEM education is. Leader B added even government agencies will discuss STEM by simply stating there is a need for more math and science in our schools. He emphasized there is not a need for more math and science, but "we need better math and better science and we need it integrated so that children don't have to ask the question why am I doing this." In STEM Leader B's organization, their focus is on the whole STEM process and implementing better strategies for instruction in the areas of math and science.

Leaders A and C agreed teacher preparation is crucial in an elementary STEM program. Both leaders felt most teachers are not ready for a STEM curriculum once they graduate college. Leader A is part of an organization that gives teachers experience as STEM learners so that when they are in the classroom they are "STEM-capable and are developing STEM-capable students."

Leader C expressed teacher education needs to be changed to include STEM. Leader A was the only individual to introduce the following challenge:

> A huge diversity piece, seeing all people as capable and recognizing that as a nation we are going to benefit the more we reach out to different men and women; white, black, brown, yellow, red, however you want to define people. The diversity is fought at a table for problem solving is within our best interest.

She stated women and people of color are quite a minority in STEM fields, and it is important to realize everyone is STEM-capable.

Table 3

Challenges Faced in STEM Education

Participant	Response
STEM Leaders A, B, C	Community/parent perception of STEM
STEM Leader B	Implementing better strategies for math and science instruction
STEM Leaders A, C	Teacher preparation
STEM Leader A	Realize everyone is STEM capable

Note. Column one indicates the STEM leader interviewed and corresponds to column two with the response. The interview question asked the participant what challenges we as a nation face in regards to STEM education.

Interview question 4. Should there be curriculum requirements in order to become a STEM school? Why or why not?

For STEM Leaders A and C, both automatically said, "Yes," to STEM schools having curriculum requirements. Leader A reinforced, "If there is a designation, there should be something behind it that has some sort of common understanding of what that designation is." Leader C acknowledged, "We do not have true STEM schools in Missouri; we have some that claim they are." He characterized STEM schools as having a curriculum where all departments must interact in order to reinforce the information being taught.

Leader B expressed in regard to the curriculum itself, it should be "well-founded in math and science. They should have a strong language component, both written and oral." He also felt STEM education should not just center on writing, but communicating orally and the ability to work in teams by interacting with other people. Leader B also noted it is more about the process and pedagogy in STEM education versus the qualification of a curriculum.

Leader A concluded with the idea of best practices in STEM. She suggested a STEM school needs to be not only "talking the talk, but walking the walk." Finally, she reiterated a need to have a better understanding of what STEM is and to continue to hold onto high standards.

Interview question 5. What professional development should teachers receive to prepare for teaching in a STEM school?

All three STEM leaders had different interpretations of professional development for teachers in a STEM school. Leader A communicated there are two main challenges. The first challenge is helping teachers see themselves as STEM capable. The second challenge is helping teachers see that STEM is everywhere. She also conveyed the STEM mindset is one of a problem-solving mentality. Leader B mentioned again the importance of understanding the pedagogy and the process of teaching and learning in a STEM educational system.

Leader C referred back to a previous answer and remained adamant professional development must start at the collegiate level. He asserted colleges must allow their teacher candidates to "have experiences in hands-on learning." He also articulated STEM professional development must be integrated into the individual schools where it has to be adapted, allowing all the teachers to come together.

Interview question 6. What have been the most observable outcomes within STEM education to date?

Leaders A and C both noted an improvement in academic achievement as one of the most observable outcomes within STEM education. Leader A is involved in an initiative where student achievement is tracked, and the organization has seen improvement in achievement in students who are in classes where the teachers have gone through a year-long training provided by STEM Leader A's professional STEM organization. Data from end-of-the-year assessments of students with STEM-trained teachers versus non-STEM trained teachers were compared, and the results indicated there is in fact growth in academic achievement for STEM-trained teachers. Leader C has focused on American College Testing (ACT) scores. He stated the ACT scores in Missouri are starting to increase, and this is more prevalent in schools with a STEM-based program.

Leader B stated when students go through a STEM program; they are "really good team players and team leaders. They are very good problem solvers, they are very good critical thinkers, they are very good at time management, they are very good at data and collection and analysis." He indicated these are critical skills businesses need and cannot be taught. He concluded with the fact these skills are what really prepare students for the workforce and for college. Leader C also stated STEM students are going into the workforce and getting jobs more quickly.

Interview question 7. What concerns do you have about elementary STEM education?

Leader C remained consistent in his responses by maintaining teacher training has to come first. Teachers must be prepared with hands-on interaction in science and mathematics. He articulated in order to have a successful STEM program, the instruction must come back to science and math being introduced and emphasized as teachers go through their STEM structure.

Leader A reiterated there is not a clearly understood criteria of what STEM means. She also suggested STEM education needs to be more than just a "reframing of science education." Her organization has introduced interdisciplinary plans that have been successful.

Leader B continued to indicate the pedagogy of STEM education must be unique from a traditional elementary program. He suggested to put emphasis on the process of STEM education being more than "plopping down STEM; it's not going to work." He was very passionate in speaking about STEM education in that it "is engaging the entire kid; it is engaging not only their mind, but it is engaging their physical, their spiritual. They just get engulfed in what they are doing." He has experienced that once STEM is brought into one school, surrounding districts and parents want to be involved as well. All results are shown in Table 4.

Table 4

Concerns About Elementary STEM Education

Participant	Response
STEM Leader C	Teacher training must come first
STEM Leader A	Need for a clear definition of STEM
STEM Leader B	STEM must be a unique pedagogy

Note. Column one indicates the STEM leader interviewed and corresponds to column two with the response. The interview question asked the participants about the concerns they have about elementary STEM education.

Elementary principals from STEM schools in Missouri. To assure anonymity, each principal was assigned a data code. For example, the first principal interviewed was referred to as Principal A, and the second principal interviewed was referred to as Principal B.

Interview question 1. How do you define STEM education?

All three principals used the words "incorporating" and/or "integrating" when defining STEM Education. Principal A simply stated STEM education is "incorporating science, technology, engineering, and math into all aspects of learning for the student." Principal B expanded on the integration piece to say, "It's more about finding a connection between those areas and really helping students to be better critical thinkers, problem solvers, and just more creative." Principal B also added the different topics in STEM fall into:

> An umbrella that allows us to pull in the literacy, the arts, and everything else that tie into those areas. That kind of umbrella guides the instruction and the learning for the students to really get them to focus on that problem-solving process.

Principal D was the only principal to mention the skills of science, technology, engineering, and mathematics need to be incorporated at a young level.

Interview question 2. When did your school become a STEM school? Briefly outline the process.

All the STEM principals interviewed have been utilizing a STEM-focused curriculum for five or fewer years. Principal D was approached by his district two years ago to begin implementing the Project Lead the Way modules in order to provide STEM for his students. Principals A and B have been involved with STEM the longest, with Principal B starting the STEM conversation in the 2010-2011 school year and Principal A in the 2011-2012 school year. Both these principals also stated their STEM programs originated from the idea their schools needed to do something different in order to improve test scores.

Principal B indicated his school was in need of academic achievement improvement because of state test scores, and the school also needed to increase enrollment. His focus was “entirely about transforming our school into something unique and different.” He also attributed the process to “kind of stumbling upon STEM because it was becoming more and more popular at that time in the United States.”

Principal A indicated the “free and reduced population was going up, and the test scores were declining.” Principal A’s school functions on a lottery system across the district for the enrollment of their students. Both Principals A and B had research teams and a lot of planning in the year leading up to their schools becoming STEM schools. Principal B and a group of teachers traveled to STEM schools in Minnesota, because elementary STEM schools in Missouri could not be found at that time.

Interview question 3. What are your curriculum requirements?

All four principals interviewed follow the curriculum established by the MODESE, including the Missouri Learning Standards. In addition, Principals D and C utilize the Project Lead the Way modules to support STEM integration. All four principals stated they are following the same curriculum as the rest of their schools within their districts, but have altered it in a way to focus more on STEM. For example, Principal A pointed out her school implements more of an inquiry-based process to deliver instruction. Principal B stated his school "revised and adapted the district's curriculum a little bit to make it fit more under the umbrella of STEM." He also focused on "understanding by design and backward design for our units."

Principal B was the only person to mention the use of the Next Generation Science Standards (NGSS). The NGSS fit under the three categories of life science, earth science, and physical science, and he focuses on one unit each trimester. Principal B continued with this by stating, "As a building, everyone K-5 would be working on life science at the same time, physical science at the same time, and earth science at the same time." Finally, Principal B always has a culminating project for the students at the end of each unit to show they understood, in addition to showing what they have learned up to that point.

Interview question 4. What benefits have you seen from becoming a STEM school?

Each principal interviewed provided distinctly different responses to this question. Principal A felt the biggest benefit to her school was the student-centered aspect of instruction. She also felt being a kindergarten through sixth grade building provides a more nurturing environment where the older kids are teaching the younger kids. Principal C noted getting the parents' buy-in and support of their school has been the greatest benefit. She suggested the parents are excited and have a feeling of ownership of the school. Principal D acknowledged, "Each kid loves what they are doing." There is "high engagement, high learning, and fun." The results are shown in Table 5.

Principals C and D both mentioned teachers in their response. Principal C found teachers have really embraced doing things differently and engaging the students. Principal D expressed the "teacher's understanding the power of self-directed learning, the inquiry learning, and the hands-on experiences and trying to make lessons more rigorous and relevant" have all been a benefit of STEM.

Principal B was the only principal to note the perceptual change in students. He saw a change in the way students view themselves. In the early stages of becoming a STEM school, his counselor gave the students an informal assessment about what they thought a scientist looked like. Almost all the students "drew a picture of some sort of Einstein, crazy guy, white hair, crazy hair, lab coat, and glasses." Principal B's building has 92% poverty and 60-70% minorities, so the students were not drawing people who looked like them. Therefore, the "biggest change that we saw right away is the self-perception, they started to view themselves as scientists." He stated the district also saw growth in test scores, mostly at the building level, with literacy rates increasing because kids were reading and understanding more.

Table 5

Benefits from Becoming a STEM School

Participant	Response
Principal A	Student-centered aspect of instruction
Principal B	Perceptual change in students
Principal C	Parent support and buy-in
Principal D	Increase in rigorous and relevant lessons

Note. Column one indicates the STEM principal interviewed and corresponds to column two with the response. The interview question asked the participants what benefits have been seen from becoming a STEM school.

Interview question 5. What impact has your STEM school had on student engagement?

The increase in student engagement was a unanimous response across all four principals interviewed. Principal A stated, “It is rare to see a student that is not engaged.” Principal C attributed the increase in engagement to the motivation of the students. Principal D stated engagement has “sky-rocketed, and students are super engaged and super motivated to learn.”

Principal B went into the most detail by explaining an informal study he conducted in his school. He took the behavior data for his students and found about “95% of the time the kids were getting referrals, they did not have technology in their hands.” Principal B also expressed the engagement has to do with how comfortable the teacher is with technology, which results in students being much more engaged in the instructional process.

Interview question 6. What impact has your STEM school had on student achievement?

All four principals have seen an increase in academic achievement since becoming a STEM school. Principal B has seen the most improvement in the building-level reading assessments in addition to the state assessments. Principal C felt overall there is an increase in student achievement, but the district still has "many obstacles with many of our students as far as prior experiences, outside experiences, those kinds of things."

Principal D was unique in that his district has always had high achievement, but he has seen an increase in the reading scores, whereas math and science have stayed strong. Principal A was the only principal to address other areas of academic achievement. While the results indicated her school is ahead of the district average on Missouri Assessment Program (MAP) scores, also indicated, "They have the highest attendance rate in the district, the lowest discipline referrals in the district, and probably the most parent involvement in the district." Principal D also mentioned the variables in place when looking at MAP test scores. This is due to the fact of the continuous change of the test format, making it difficult to compare scores from year to year.

Interview question 7. What professional development did teachers receive to prepare for teaching in a STEM school?

Each principal had a different response as to what the best professional development for their teachers was. Principal A felt a person who was brought in from outside the district and provided multiple days of professional development about inquiry-based learning was the best for her school. She also added the collaboration among the teachers within each grade level is very beneficial. Principals A and C are utilizing the Project Lead the Way module; therefore, they received intense training from the leaders of this organization. This program provides hands-on training, online modules, trainings, and quizzes. Project Lead the Way is a train–the-trainer model where one person in a building is trained and that person comes back and trains everyone else. However, both Principals A and C sent at least one teacher per grade level to the training.

Principal B has also had several teachers over the last few years participate in the Quest program, the STEM conference, the Science Teachers of Missouri conference, and other conferences pertaining to STEM. Recently, Principal B has moved more toward inward-focused professional development including grade-level meetings every week. During this time, teachers talk about what lessons are coming up, design a lesson together, and then one person offers to teach that lesson. Principal B would get substitutes for the other teachers so they could be released to watch the lesson being taught, and then the team would all sit down and talk about what went well and what they could do differently. This allowed the teachers to make themselves better and help each other become better teachers.

Principal C was the only principal to mention having a STEM specialist in the building. This specialist is able to provide "on-the-job professional development all day long." The specialist works with teachers on their curriculum guides, sets goals, and ensures they are incorporating literacy and math in all the units.

Interview question 8. What impact has STEM had on teacher attitude in regards to the implementation of STEM?

All four of the principals had similar responses in regard to teacher attitude toward becoming a STEM school. Principals B, C, and D all agreed teachers were skeptical or uneasy in the introductory phases of STEM, but have grown to like it and have become believers in what they are teaching. Principal B emphasized STEM made a difference in the culture and climate of his building by stating, "STEM kind of leveled the playing field for all of our teachers since there was no one expert in STEM, it didn't matter your years of experience." He also assessed the teachers became much more confident over the years with the professional development they received and became more comfortable teaching STEM and learning.

Principal D became aware of the confusion that STEM created. His teachers became very uncomfortable to fail while learning a module and they wanted to quit their training. However, once they saw their kids starting in on the same modules and how quickly the students became engaged, the teachers knew it was powerful. Principal D concluded, "When we start talking more about 21st century learning workforce and competencies and how the world is changing, it helped kick them into gear." He was quick to point out he was of the same skeptical opinion at first, but has quickly become a believer as well.

Interview question 9. What have been the most observable outcomes within STEM education to date?

Principals A and D both advocated STEM education had created more interest in lessons and engagement from the students. Principal A specifically explained that through inquiry-based instruction, teachers are creating students who are inquisitive and thinking, thus figuring out the answer for themselves.

Principal C noted the excitement of the parents to be the most observable outcome. She has been able to see how excited the parents are about their children going to a STEM school. Due to the fact her school is a lottery school; it has changed the population and brought in different students who might not otherwise attend based on district boundaries. She continued with the overall teacher autonomy and excitement about science and feelings of empowerment about the STEM subjects.

Principal B provided the most detailed response for what he thought to be the most observable outcomes within STEM education. He expressed:

> STEM education overall has really just brought to the forefront that we are kind of lagging when it comes to science and engineering and mathematics, and good problem solvers, and kids being creative and being able to analyze things and research things and figure stuff out.

He conveyed today's society is one where individuals must be able to think, analyze, and research to solve problems.

Principals A and D were in agreement that the "sit and get" traditional way of teaching and learning is fading. Teachers' roles are changing, and they are now becoming more of a guide and support for students, and are no longer the "sage on the stage." It is the role of teachers to provide a hands-on, engaged, problem-solving, critical thinking environment.

Interview question 10. What concerns do you have about STEM education in general?

All the principals interviewed were very positive about STEM education. Principal D did not have any concerns about STEM education in general and reported that once his building was introduced to the idea of being a pilot school for STEM, "It took just a few weeks for me to see the power of STEM." These results are indicated on Table 6.

Principal C had one concern about her school, which is currently a Title school. She expressed concern:

> Just because we are a STEM school, it isn't going to immediately change those test scores, that we still have obstacles that we still have to overcome. In other words, I have this concern of giving up on STEM because it is not this huge increase automatically.

To conclude, Principal C reiterated the concept of STEM is the direction that today's education is headed.

Principal A was the only participant to mention the preconceived generalization about women not belonging in math and science. She professed a concern would be to make sure there is equality across all the STEM subjects. She continued with her concerns by explaining the United States is not producing enough STEM workers to meet the demands of our society, so the more we can do now to get students excited early, the better.

Principal B's main concern for STEM education was that "people might still view it as content and when most people hear STEM, they just think oh, we are teaching more science or we are teaching more engineering concepts." He also noted people do not view STEM as a process or a way of teaching differently. Science, technology, engineering, and mathematics is also about encouraging creativity and problem solving, and Principal B expressed doubt everyone fully understands that about the integration of STEM.

Another concern this participant had was the “watering down” of the STEM curriculum by trying to implement more art into education. He conveyed the opinion that if not careful, trying to integrate more art into a STEM school could “destroy the analytical, rational, and critical thinking side of stuff, the problem-solving side by just being creative and having no use for whatever it is you develop.” Therefore, it is important to find a balance in the STEM curriculum to ensure the integrity of each content area is maintained.

Table 6

Concerns About Elementary STEM Education

Participant	Response
Principal A	Ensuring equality in STEM
Principal B	Finding a balance between STEM and the arts
Principal C	Giving up on STEM too quickly if gains are not seen
Principal D	None

Note. Column one indicates the STEM principal interviewed and corresponds to column two with the response. The interview question asked the participants about the concerns they have about elementary STEM education.

Elementary teachers from STEM schools in Missouri. To assure anonymity, each elementary STEM teacher was assigned a data code. For example, the first elementary STEM teacher interviewed was referred to as STEM Teacher A, and the second STEM teacher interviewed was referred to as STEM Teacher B throughout the interview portion.

Interview question 1. How do you define STEM education?

The most common words used by the six interviewees to define STEM education included inquiry-based learning, integration, marrying, blended, and project-based learning. Elementary STEM Teacher A was the only teacher to state STEM education is "the focus on science, technology, engineering, and math." Teacher B emphasized that for him, "It means more real-world science and math being taught throughout your entire curriculum." Teachers C, D, E, and F all felt STEM education is more of a combination of all four disciplines and bringing them all together. Teacher D defined STEM education as:

> Integration, project-based learning, and I would say you have to look at the big idea of STEM and from there look at teaching math, reading, and writing to take kind of the big units of studies and from there make lesson plans.

Teacher C went one step further in her definition to mention that STEM education has to do with "an approach that is used to teach, not necessarily the content." Teacher A was the only teacher to provide an answer including students by emphasizing the students are more the leaders in a STEM curriculum, and the teachers are simply the facilitators.

Interview question 2. When did your school become a STEM school? Briefly outline the process.

Teachers C and D teach in the same school and both stated the district had goals to improve academic achievement and to increase enrollment in their building due to not making expected progress. Their school boundaries include a lot of students in poverty, which prompted the district to approach their school to make a big change. Five years ago, in 2010, a team of teachers and the principal visited STEM schools in Minnesota to see how STEM was being implemented. They then had a "world café event where the community got to come in and we kind of looked at areas of parent involvement, curriculum, professional development, and kind of got some ideas there." Teacher C stated this had been a "learning progression as we had gone on." The first two years consisted of a lot of changes in the physical appearance of the school and in the different programs being offered after school. It was not until the second year that the building staff focused on the curriculum and how they were teaching.

Teachers A and B went through a similar planning process that included the district creating various focus groups. Teacher A said, "Various groups throughout the community, including teachers, administrators, and parents," were brought together to design what they wanted the school to look like. This was a year-long process, and all the information gathered was taken to the school board to be approved at the end of the process. The building has now been functioning as a STEM school for three years.

Teachers E and F are employed within a school district that approached their building to offer more innovative ways of teaching. As a result, two years ago the building staff members began implementing the Project Lead the Way modules. Their school staff are now serving as the trainers for the other nine elementary schools within the district.

Interview question 3. What are your curriculum requirements?

All the teachers interviewed maintained they still follow the curriculum their respective districts have adopted. Teacher A explained they have a "set curriculum that has been approved by our board of education, but we are a little bit more lenient in the fact that we can take strands and teach them however we want to." Teacher B, from the same school as STEM Teacher A, added teachers are expected to instruct in an inquiry-based manner and implement lessons that are "real-world." He continued, "It was really an opening up, and the expectation was to make learning real and make kids discover their own learning."

Teachers C, D, E, and F all specified the use of the Missouri Learning Standards and the Next Generation Science Standards in their curricula. Teacher C clarified by saying, "We design and pull together a wide range of curriculum materials to find what best fits the approach that we have." She continued, "We start with the standards, and then we design a progression of lessons that hit those standards using a variety of material." Teacher F also reported his building has switched Missouri State Standards around the different grade levels to help better align with the Project Lead the Way modules.

Interview question 4. What benefits have you seen from becoming a STEM school?

All the teachers interviewed answered interview question four with a student-centered response. Teacher A was very passionate about her STEM school, because students are more engaged in the lessons due to the hands-on and inquiry-based learning. Teacher B focused on students becoming problem solvers and critical thinkers. He said, "When you say something to them or provide a limitation to their learning or thinking, their response isn't just compliance or just acceptance, they want to figure out how to solve it and how to change it."

Teachers D and E both mentioned project-based learning and giving the kids the big picture. Teacher D focused on one big idea and taking it to learn in numerous ways. She provided an example of one of her students who did not know how a polar bear could swim in the water. The student "researched it, he wrote about it, he engineered a habitat, he engineered an animal, and he was able to present it and then we made a website." This enabled the class to tie it all into the STEM aspect. Teacher E expressed STEM education is providing an outcome basis for students.

Teacher C was quick to comment the community support, both financially and physically, was a great benefit to becoming a STEM school. The local university science and engineering departments became very interested in seeing how they could help with the STEM programs. The other benefit was having very motivated teachers to be a part of a STEM school. The teachers were given the option of going to a different school; therefore, those who remained or transferred were there for STEM.

Teacher F felt the opportunities STEM has allowed his students has been the greatest benefit. He has been able to see the students "blossom" from one year to the next in terms of learning. He added the benefit of his building being on the forefront of innovation within the district, and other schools are able to see the positive changes occurring with STEM. All results are shown on Table 7.

Table 7

Benefits from Becoming a STEM School

Participant	Response
Teacher A	Increased student engagement
Teacher B	Students becoming problem solvers and critical thinkers
Teachers D, E	Project-based learning
Teacher C	Community support
Teacher F	Increase in opportunities for students

Note. Column one indicates the STEM teacher interviewed and corresponds to column two with the response. The interview question asked the participants what benefits have been seen from becoming a STEM school.

Interview question 5. What effect has your STEM school had on student engagement?

All six participants were in agreement the introduction of STEM did nothing but increase student engagement. Teacher B reported her school has an extended school year with an extra 20 days when compared to the other elementary schools in the district, and estimated student engagement to have "doubled or tripled" since changing to a STEM school. Teacher A is from the same school as STEM Teacher B, who added the instruction is more student-centered, so the students have a lot of input as to the process or the product of what it is they are doing and learning.

Teacher D was bold enough to say that she "one hundred percent believes that STEM has a huge impact on student's learning." She related back to the reason she became a teacher in the first place and how she learns best, which is hands-on learning and real-life experiences. She was steadfast in saying STEM education covers all of those bases extremely well.

Teachers C and F both felt STEM offered some of the more hesitant students a way to become involved. Teacher F reported the students who normally do not succeed are becoming leaders in the classroom with all the opportunities STEM has to offer. Teacher C commented some of the more active boys in her class have increased engagement due to the hands-on learning experiences students can take and then read and write based on what was learned.

Teacher F was the only teacher to point out the overlap of STEM into the other content areas. He said the success and the level of engagement seen in the STEM areas is "really changing how we are looking at things the rest of the day as well." He also continued with saying the high engagement is reflected in the lack of behavior issues as well.

Teacher E stated the students' "interest level is so much higher and their ability to pick and choose and where they are going in the next phase is new to them." She continued with saying that this learning is new for the teachers, too.

Interview question 6. What professional development did you receive to prepare for teaching in a STEM school? Please describe the usefulness, quantity, and the continuity of this professional development.

All six elementary STEM teachers interviewed went through rigorous and time-consuming professional development both before teaching in a STEM school and while currently teaching in a STEM school. Teachers C and D were the only teachers to visit other schools during the initial process of becoming a STEM school. Teacher C reflected on the fact of this being the best type of professional development, because teachers were able to see an elementary STEM school in action.

All the participants have attended numerous conferences including regional, national, and area STEM conferences in addition to the building-level professional development offered by their school districts. Teachers A and B were both very passionate about the Science Curriculum Coordinator/Director. Their school brought in this person, who was a veteran science teacher, for a week before school started. She walked the teachers through the process of what a science classroom should look like. She also focused on engineering and provided her time and resources to each teacher. In addition, she met with grade-level teachers once a week for an hour to plan new units and to discuss learner objectives. Teacher B indicated that this was "singlehandedly the most useful experience she had."

Teachers E and F specifically mentioned the Project Lead the Way training they were offered. Their school sent two teachers per grade level to the training Teacher F depicted the training as "incredibly intense, and there was a lot of work we did before, and there was a lot of work even at night during the training." As a result, the lead teachers from their building are now providing training for the rest of their district.

Teachers B and C implied facilitating and growing leaders within one's own building is a great way to incorporate professional development. For example, STEM Teacher B recognized the Science Curriculum Coordinator "ignited a fire within each teacher, and we have kind of become experts in certain areas and we provide professional development to each other." Teacher C illustrated her professional development as one that has transitioned to classes based on the needs of the teachers. Staff members are able to look at what highly effective instruction they need as teachers and what they need to learn more about and then design the professional development around that.

Interview question 7. What effect has the implementation of STEM had on teacher/student attitude?

In response to this question, all six elementary STEM teachers interviewed felt the implementation of STEM has had a very positive impact. Teacher F reported, "The student attitudes have been terrific, and I think the teachers have seen the benefits of it and it has been a very positive experience, and I think it has made them realize that they want to do more like this in the rest of the day." In addition, he generalized teachers are trying to find ways to incorporate some of the STEM activities in even more areas than the science, technology, engineering, and mathematics disciplines.

Teacher E was the only teacher to classify teachers as "kind of cautious from the beginning." As a result, teachers worked collaboratively, and each teacher was paired with another teammate to teach the Project Lead the Way modules. Teacher B reported teachers are more positive because "we had so much more freedom and we aren't really locked down." He also made mention of the support of his building principal, which has led to more of a team atmosphere in figuring out what an elementary STEM school looks like.

Teachers A and C mostly talked about student attitudes in response to this question. Teacher A expressed STEM creates a positive learning atmosphere in the classroom as opposed to the teacher just presenting information and the students taking notes. Teacher C conveyed STEM allows students to be less hesitant to try new things, which helps their attitude because they are more interested in trying science and engineering. She has also seen a shift in the attitudes of students, because no matter where they come from, "They see themselves as scientists, they see them as engineers, our girls are more likely to jump in and try some of the activities then when prior to becoming a STEM school."

Teacher E shared a personal story regarding student attitudes toward STEM. She was with a group of moms and one of them said, "I am planning my son's sixth birthday party, and he wants an engineer party, like an engineer who makes cars and makes cars go and that whole thing." For STEM Teacher E, this spoke volumes about where the interests of kids are today. She continued with saying that as a STEM teacher, she realizes students cannot wait for the next STEM project and are always eager for the next thing.

Interview question 8. What have been the most observable outcomes within STEM education to date?

All six interviewees had relatively different responses to this question, but all were related to student achievement or success. Teacher A summarized by saying as an upper elementary level teacher, she has had to constantly evolve and change her science lessons because her students have already received skills in the lower grades. Therefore, she needs to provide them with additional extension information, going one step further.

Teacher B noted the biggest outcome has been the fact kids never stop learning. He reported kids are more connected within his building, and their work ethic is tremendous. He also noted, "My MAP scores are tremendously higher than they were when I was not teaching in a STEM school. I would say nearly double or triple for the last three years." Teacher C also mentioned student growth in her STEM school. She explained not only are academic gains obvious, but the overall attitude of her kids and the ability for them to see how what they are learning applies to the real world has improved over the last few years. Teacher D acknowledged STEM showcase as a great outcome for her school. This is an event twice a year where numerous STEM professionals come in and present their specific professions. This allows students the opportunities to see many different career paths that are available to them at such a young age.

Teacher E was the only teacher to mention student motivation as the most observable outcome. She suggested the students are finding real life uses for the skills they are being taught. This in turn results in the students working at a higher level, because they know it is "real work for real people." Teacher F gave a specific student example as the most observable outcome he has seen in STEM education to date. This student had an individualized education plan, and "he is not the kid who gets the highest scores on everything, he is the kid who gets frustrated with his work and sits in the room and cries because he is so frustrated." However, once introduced to engineering and building robots, he "took off and blew me away when it came to explaining what he was doing." In the end, this student was asked to present to a group of teachers from different schools, and "he stole the show." Teacher F was very passionate about STEM education and what it can provide students who may not have success in other areas.

Interview question 9. What concerns do you have about STEM education in general?

As shown in Table 8, all the elementary STEM teachers had valid yet distinctly different concerns in regards to STEM education in general. Teacher F was resolute about not wanting STEM to become another buzz word that gets thrown around. He noted STEM is quickly becoming big and fears it may become something that is "trendy so people feel like they have to do it." Teacher E was concerned about the whole piece of fitting in all the standards and being able to do each standard justice. Teacher D was very passionate about STEM education and the opportunity to learn about it and how to teach it, but thinks that it can be intimidating due to the amount of information that is hard to integrate. She was quick to point out all the research that supports STEM education and that being able to integrate real-life experiences and project-based learning will only help to enrich learning.

The concern for STEM Teacher C is that there is not a clear definition for STEM education. She espoused educating the community on STEM education and how it applies is crucial for the success of STEM in an elementary school. Teacher B's concern is that STEM might become "a one-size-fits-all, bottled-up elementary STEM program." He expressed worry people are trying to make STEM a "token experience" rather than a true real-world, inquiry-based experience.

Teacher A was concerned about the continuation of making sure the activities and lessons provided are age appropriate for her students. In addition, she voiced the importance of ensuring students have a foundation of skills in order to continue with STEM education. Students must have a good basis of math and science knowledge before progressing to inquiry and investigative types of learning approaches.

Table 8

Concerns About Elementary STEM Education

Participant	Response
Teacher A	Making sure lessons and activities are age appropriate
Teacher B	Strict programs to follow
Teacher C	There is not a clear STEM definition
Teacher D	STEM is intimidating due to the amount of information
Teacher E	Ensuring all the standards are being taught
Teacher F	Fear of becoming too trendy and then discarded

Note. Column one indicates the STEM teacher interviewed and corresponds to column two with the response. The interview question asked the participants about the concerns they have about elementary STEM education.

Summary

This qualitative study was conducted to gain an in-depth understanding of the perceptions of elementary STEM schools in the state of Missouri through the analysis of responses to interview questions. The concept of elementary STEM education is currently a much-publicized topic in the education community. In this study, the viewpoints were all extremely supportive of STEM education at the elementary level.

Chapter Four included the perceptions and opinions of various stakeholders involved in the STEM education community within the state of Missouri. Interviews with elementary principals and teachers in STEM schools and leaders in professional STEM organizations were analyzed. In this study, the perceptions were those of enthusiasm and passion for the field of STEM education.

The findings from the analysis of data and a summary of these findings are presented in Chapter Five. Each of the research questions is revisited, and conclusions are discussed. Implications for practice are addressed, and recommendations for future research concerning STEM education are presented.

Chapter Five: Summary and Conclusions

Science, technology, engineering, and mathematics education is a topic of great interest in education today. The exploration of STEM education continues to grow in importance in the realm of education. Science, technology, engineering, and mathematics education is a way of teaching and learning that is project-based and focuses on real-world problem solving (Tennessee STEM Innovation Network, 2012). In order for the United States to maintain their competitive stature in the global economy, students must be introduced to STEM opportunities at an early age in order to get them engaged in STEM education (Science Pioneers, n.d.).

Research has shown the United States is not performing well on science and mathematics tests when compared to other countries (Hom, 2014). Studies have also shown jobs in the STEM field are growing at 17% compared to other fields at 9.8% (Science Pioneers, n.d). As result, business leaders, industry experts, and even politicians are rallying around the status of STEM education and the importance of creating a STEM-educated workforce (Murphy, 2011).

This qualitative study was designed to examine the perceptions of elementary STEM teachers and principals and leaders in professional STEM organizations on elementary STEM schools in Missouri. Because most of the research on STEM education has been conducted at the junior high and high school levels, there is little research on elementary STEM schools. In this final chapter, the research questions that guided the study are answered, and data are presented to support the findings. In addition, conclusions, implications for practice, and recommendations for future research are provided regarding STEM education in elementary schools.

Findings

For the purpose of this study, four research questions were presented to obtain qualitative data about the perceptions of elementary STEM schools in Missouri. After the examination and analysis of the responses from leaders of professional STEM organizations, elementary STEM school principals, and elementary STEM school teachers, the findings were summarized and then applied to the corresponding research question. In addition, relevant literature from Chapter Two was discussed to compare with the findings of this qualitative study.

Research question 1. What are the perceptions of elementary principals in STEM schools regarding teacher attitude toward the implementation of STEM?

During the interviews with each elementary STEM principal, participants were asked the question, "What impact has STEM had on teacher attitude in regards to the implementation of STEM?" All four of the principals had similar responses in regard to this question. According to the Carnegie Science Center (2014), one of the major obstacles in STEM education is the misperception teachers have pertaining to STEM. Teachers feel STEM is too hard to teach and too difficult to fit into the content areas they are used to teaching (Carnegie Science Center, 2014).

Principal D responded in a way that is consistent with the Carnegie Science Center (2014). He became aware of the confusion STEM created once his district decided to implement it into his building. His teachers became very uncomfortable to fail while learning a Project Lead the Way module and wanted to quit their initial training. However, once the teachers saw their kids starting in on the same modules and how quickly students became engaged, the staff knew it was powerful. Principal D concluded, "When we start talking more about 21st century learning workforce and competencies and how the world is changing, it helped kick them into gear." He was quick to point out he was of the same skeptical opinion at first, but has quickly become a believer as well.

Another obstacle discussed by the Carnegie Science Center (2014) is issues inside the classroom. This includes older teachers who are not motivated to embrace STEM and instead simply teach to the test. Principals B, C, and D all agreed teachers were skeptical or uneasy in the introductory phases of STEM, but have grown to like it and believe in what they are teaching. Principal B emphasized STEM made a difference in the culture and climate of his building. He stated, "STEM kind of leveled the playing field for all of our teachers since there was no one expert in STEM; it didn't matter your years of experience." He also assessed the teachers have developed more confidence over the years and are more comfortable teaching STEM and the learning process.

Research question 2. What are the perceptions of teachers in STEM schools regarding student engagement?

Student engagement can be defined as "the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught" (The Glossary of Education Reform, 2014, para. 1). All six elementary teachers were asked, "What effect has your STEM school had on student engagement?" Every participant was in agreement the introduction of STEM has done nothing but increase student engagement.

Teacher B estimated the student engagement in his building "has doubled or tripled" since transitioning into a STEM school. Teacher A said instruction is more student-centered, allowing the students to have more say as to the process or the product of what it is they are doing and learning. Teacher D stated she "one hundred percent believes that STEM has a huge impact on student's learning."

Teachers C and F gave similar responses regarding student engagement. They both said STEM education offers some of the more hesitant students a way to become involved. Teacher F reported the students who normally do not succeed are becoming leaders in the classroom with the opportunities that STEM has to offer. Teacher C also noted the hands-on learning STEM provides has increased the engagement of the more active boys in her class, and the boys are taking that approach to reading as well.

Teacher F was the only teacher to mention high engagement with STEM content is having an impact on the lack of behavior issues in the classrooms. He said the engagement seen with STEM is now starting to transfer to the other content areas and is changing the way teachers are "looking at things the rest of the day." Overall, none of the six STEM teachers interviewed had anything negative to say about the student engagement in STEM education.

All the responses from the participants are directly in line with the author Royal (2013) in that STEM involves facilitating learning environments that will allow students to be more active. Royal (2013) also found students who are actively engaged in their learning are better at remembering what they have learned.

Research question 3. What are the perceptions of teachers in elementary STEM schools regarding professional development?

The six elementary STEM teachers interviewed for this study went through rigorous and time-consuming professional development both before teaching in a STEM school and also while currently teaching in a STEM school. All six participants have attended numerous conferences including regional, national, and area STEM conferences in addition to the building-level professional development offered by their school districts. While they may have attended some of the same conferences, each school represented by the teachers interviewed had a different opinion as to what the most beneficial professional development was.

Teachers C and D made site visits to STEM schools in other states. Teacher C reported this was the best type of professional development, because they were able to see an elementary STEM school in action. These teachers also implied facilitating and growing leaders within one's own building is a great way to incorporate professional development.

Teachers A and B are from the same school, and even though they were interviewed separately, they were both very adamant the Science Curriculum Coordinator/Director was the best avenue of professional development for them. This individual was brought in before school started and was able to walk teachers through the process of what a science classroom should looked like. This specialist also focused on engineering and provided time and resources to each teacher. In addition, throughout the first year of becoming a STEM school, the Coordinator/Director met with each grade-level team on a weekly basis to plan new units and discuss learner objectives. Teacher B indicated this was "singlehandedly the most useful experience she had."

Teachers E and F were specific the majority of their training came from the Project Lead the Way organization. Teacher F described the training as "incredibly intense, and there was a lot of work we did before, and there was a lot of work we did even at night during the training." He felt this training has made the teachers more comfortable in teaching STEM within their buildings.

With the implementation of STEM education becoming more common, the significance of professional development for elementary teachers is quickly growing (Shapiro, 2012). According to Nadelson et al. (2012), "The link between teachers' comfort, their motivation to teach, and student learning in STEM provides good reason for attending to comfort and related variables in professional development directed at enhancing teacher capacity to teach STEM content and curriculum" (p. 70). Fisher et al. (2012) acknowledged that for professional development to provide the maximum impact, it must be implemented over time. This was in direct line with STEM Teacher D, who said her training for STEM came as early as college, when she served on the executive board of the National Science Teachers Association and had the opportunity to present at two national science conferences.

Research question 4. What are the perceptions of professional STEM organizations, elementary principals, and elementary teachers regarding the benefits of elementary STEM schools?

The professional STEM organization leaders, elementary STEM principals, and elementary STEM teachers were asked to give their perceptions on a variety of topics regarding STEM education. When asked to define STEM education, all 13 participants gave a definition consistent with Tsupros et al. (2009):

> STEM education is an interdisciplinary approach to learning where rigorous academic concepts are couple 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. (para. 3)

Leader B acknowledged STEM is "not a collection of towers," but it is more of a process. He went on to state STEM is a process of "helping students to be able to not only function in school, but to function outside of school in their future, so it's a process of being able to utilize what they are learning." Leader A was the only STEM organization leader to directly refer to the four distinct content areas which form the acronym STEM.

All four principals used the words incorporating and/or integrating in their definitions of STEM education. Principal B began by saying, "It's more about finding a connection between those areas and really helping students to be better critical thinkers, problem solvers, and just more creative." Principal D was the only principal to mention the fact about STEM education being incorporated at a young level.

The elementary STEM teachers provided the lengthiest and most in-depth definitions of STEM education. The most common words (see Figure 3) used by the STEM teachers included inquiry-based learning, integration, marrying, blended, and project-based learning. All but two of the STEM teachers felt STEM education is more of a combination of all four disciplines and bringing them all together. All participants felt the teachers are more the facilitators of the information, and the students are the leaders in the classroom.

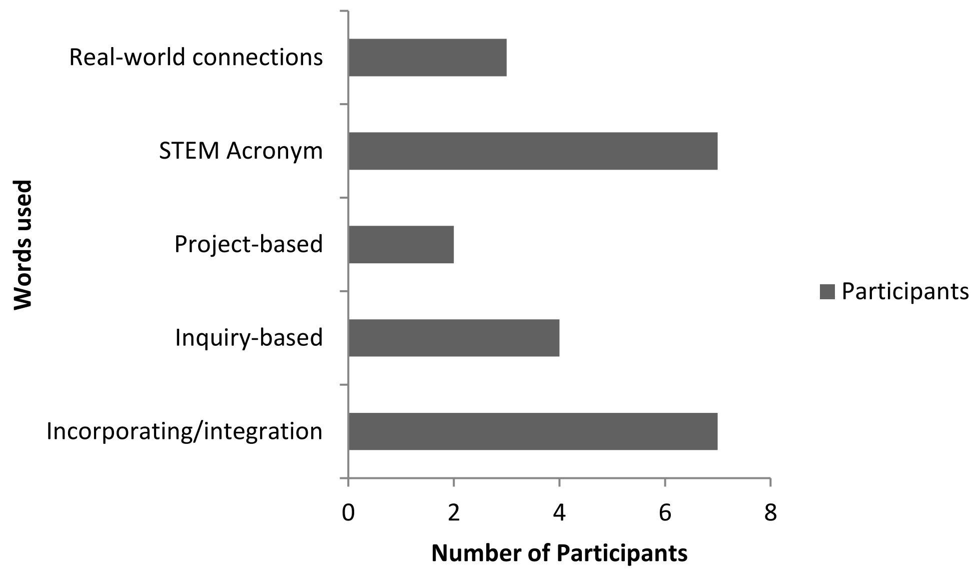

Figure 3. Common terminology used in defining STEM education. Created by the researcher to depict the number of times key words were used to define STEM.

The leaders of the professional STEM organizations were asked about the importance of elementary STEM education in the United States. Leader C stated STEM education provides students with a "better chance to see science and mathematics in action in the process before they get turned off to it." Leader B was the most absolute in his response by saying that in order to help students see how the integration of the STEM subjects work, the integration has to start at an early age to enable students to recognize they can excel in these areas.

Leaders B and C thought by the time students are in second or third grade, they have made their mind up about whether or not they like math or science. This coincides with the research from Hom (2014), who wrote the goal of elementary STEM is to create and pique the students' interest in STEM fields. Leader A was the only leader to mention the importance of STEM and the future of the workforce. She noted corporations are currently funding STEM initiatives at the elementary level because they realize:

> If kids don't see themselves as STEM capable and self-select away from some of the options available in high school, not to mention in college, then we are actually not frontloading the workforce with young people that could bring benefit to us.

This statement is supported by the Obama Administration's Educate to Innovate campaign where Obama has enlisted the efforts of leading companies, foundations, non-profits, and science engineering societies to assist in the nationwide effort to increase STEM awareness (The White House, 2013).

To conclude, STEM Leader A felt the younger STEM is introduced to all students, the more likely chance there is in diversifying the STEM workforce. According to Ricks (2012), "Early learning experiences can contribute to positive academic trajectories in STEM fields, thus a concentration in STEM at an early age can encourage children to believe they can succeed in STEM domains" (p. 43). This reiterates the importance of STEM education in elementary schools.

The elementary STEM teachers and principals were directly asked the benefits they have seen from becoming a STEM school. All the participants answered this question with an obvious passion for their careers in STEM education. When it came to identifying the benefits, all the participants primarily focused on their students and what the students have accomplished. Responses ranged from the increase in student engagement to students becoming problem solvers and critical thinkers. Teacher C was quick to mention the benefit of having a university close in proximity and the university's willingness to help with the elementary STEM programs. Principal C felt getting buy-in from the parents has been the greatest benefit. The parents are excited about the STEM school and have a feeling of ownership in the school.

This response addresses one of the obstacles mentioned by Carnegie Science Center (2014). The Carnegie Science Center (2014) found overcoming the misperceptions of parents and the public regarding STEM education was something schools had to acknowledge. Parents must be educated properly on what STEM is and that it is for everyone, no matter the academic level, socioeconomic status, or gender. Principals C and D have also seen a benefit of STEM with the teachers. Principal D stated, “The teachers’ understanding the power of self-directed learning, the inquiry of learning, and the hands-on experiences and trying to make lessons more rigorous and relevant” have been a huge benefit of STEM education.

All 13 participants were asked what they have seen to be the most observable outcomes within STEM education (see Figure 4). Student achievement and student engagement were the predominant answers in response to this question. Researchers in STEM education have found effective, challenging instruction not only covers the important math and science content, but can engage even bored, distracted, and unmotivated students (STEM Smart, 2014).

Leaders A and C both noted student achievement as one of the most observable outcomes. Both leaders have been involved with collecting data from the tracking of student achievement in different areas, and each of them have seen scores on end-of-the-year assessments starting to increase. Leader B added students who have gone through a

STEM program are "really good team players and team leaders," which are critical skills businesses need and cannot be taught within professions.

Principal A specifically noted through inquiry-based instruction, students are becoming more inquisitive and thinking, thus figuring out the answers for themselves. Principal B provided the most detailed and comprehensive response to this question. He said:

> STEM education overall has really just brought to the forefront that we are kind of lagging when it comes to science and engineering and mathematics, and good problem solvers, and kids are being creative and being able to analyze things are research things and figure stuff out.

He was passionate that today's society requires citizens who can think, analyze, and research to solve problems.

Teacher B was quick to respond the biggest outcome has been the fact kids never stop learning. He also made specific mention of his MAP scores being "tremendously higher than they were when I was not teaching in a STEM school." Teacher C pointed out the academic gains she has seen also include the overall attitude of her students and how they approach learning as a tool they can and will use later in life.

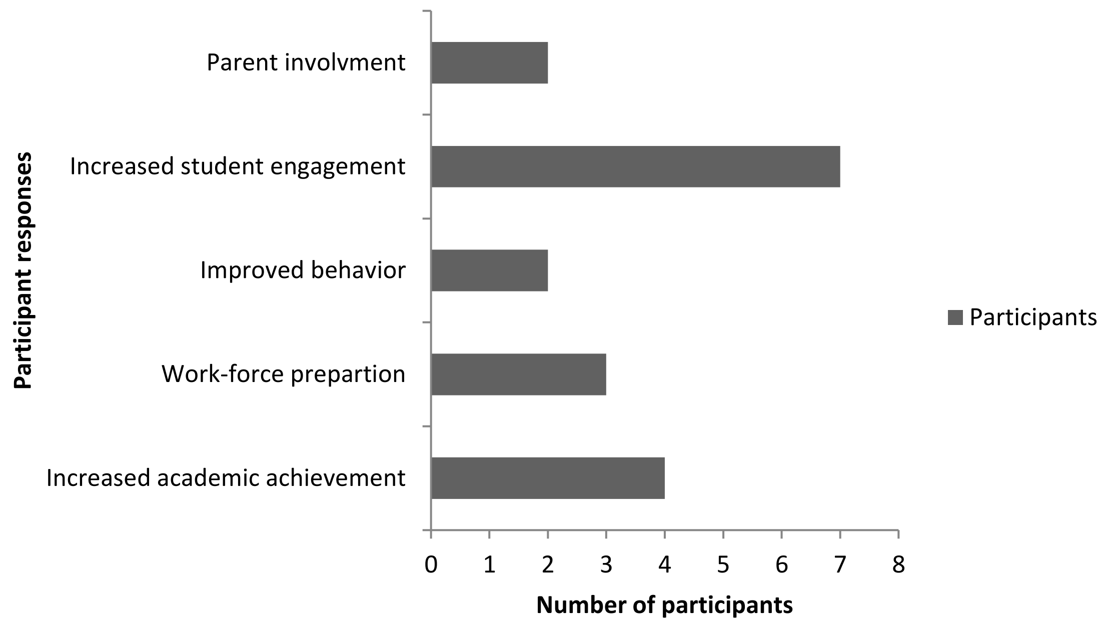

Figure 4. Observable outcomes within STEM education. Created by the researcher to depict the most commonly mentioned outcomes within a STEM education.

Conclusions

Perceptions of professional STEM organization leaders. The STEM leaders interviewed were of like mind regarding the benefits elementary of STEM education. All three STEM leaders gave similar definitions of STEM and mentioned key words such as process, reinforcement of content, project-based, real-world connections, and integration. All three leaders interviewed spoke with great concern that STEM education should begin at a young age in order to see the many advantages it has to offer. The STEM leaders expressed support of STEM education at the elementary school and the outcome of producing positive and product-driven results. Each leader interviewed mentioned either academic or social gains as one of the greatest benefits to implementing a STEM education in schools.

The dominant concern regarding elementary STEM education is not having a clearly understood criteria as to what STEM education looks like. Additionally, teacher training must be a priority in order to effectively provide the hands-on part of teaching science and mathematics. It was obvious all three of the leaders of various professional STEM organizations are passionate about STEM education and realize the important role it plays in the future of the United States.

Perceptions of elementary STEM school principals. The elementary principals interviewed for this study were all consistent in their responses about teacher attitudes towards STEM education. All the principals felt that in the beginning, the teachers were apprehensive about introducing a new way of teaching science, technology, engineering, and mathematics into the classroom. However, it was unanimous once teachers saw the engagement and excitement from the students, any resistance to STEM education was forgotten.

In reference to the benefits of elementary STEM schools, all the principals maintained student engagement is one of the biggest benefits of a STEM school. One principal was passionate about the change in how students viewed themselves. Before the academic gains came to fruition, the perceptual change in students was the most pronounced benefit in his building. The students were beginning to see themselves as scientists and engineers no matter their gender or race.

The other three principals focused on the student engagement piece as the greatest benefit, reiterating the simple fact students love what they are doing. Another benefit has been the parent buy-in toward STEM education. Parents are beginning to push for STEM initiatives in schools, because they are seeing the benefits it can offer their children for future professions.

When discussing their concerns about STEM education in general, the biggest was not viewing STEM as a process or way of teaching differently, but still viewing it as content. The principals have seen numerous benefits in their schools after implementing a STEM curriculum. Obviously, the biggest changes presented themselves in the students. The STEM principals mentioned the way students view themselves has changed. Principals are also seeing an impact on student engagement as well as motivation to learn. It can be stated all four principals interviewed are true advocates for a STEM school and continue to educate others on the importance of an early STEM education.

Perceptions of elementary STEM teachers. The six STEM teachers who were interviewed were most passionate about the student engagement piece of STEM education. Every teacher who participated in this study was of the same opinion that STEM education has increased student engagement across the board. The students are much more interested in learning and applying the concepts they are studying. The students are offered hands-on learning, coupled with real-life experiences, and they cannot wait for what is next. Since STEM education is a more student-centered versus teacher-centered environment, the students are more engaged in the lessons.

Every teacher involved in this study went through an intense professional development program either through their district or through an outside professional organization. All teachers have spent numerous hours both during the process of becoming a STEM school and currently while teaching in a STEM school. This professional development ranges from in-house activities offered by a specialist in their district or building, to attending conferences and seminars in and out of the state.

It was apparent all six teachers take pride in their jobs and want to provide the best possible instruction for their students. The STEM teachers from each school interviewed also spoke of the collaborative nature STEM has created, and teachers are continually learning new things from their peers.

Five of the teachers were very outspoken about the benefits of STEM education. These five teachers talked about nothing but the students. These benefits include project-based learning and kids becoming problem solvers and critical thinkers. The students are much more willing to look at the big picture and to learn in numerous ways. The students are more motivated to try to make sense of figuring things out in different ways.

One teacher was quick to point out the community support was the biggest benefit. The community offered both financial and physical support. This teacher also felt the motivation level of the teachers was another benefit. Teachers wanted to come to the STEM school, because they wanted to continue to grow and learn themselves and were very motivated to be a part of a STEM school.

The concerns presented by the elementary STEM teachers included not having a clear definition of STEM education, which makes it more important to educate communities to understand its importance. Communication is a crucial piece in the integration of elementary STEM education. In conclusion, it became extremely apparent each of the STEM teachers interviewed has a true passion for their chosen professions of educating future leaders in science, technology, engineering, and mathematics.

Implications for Practice

The 13 people interviewed for this study had similar and consistent opinions regarding elementary STEM education. The findings of this study indicate STEM education in elementary schools is a topic individuals involved in the STEM community feel very eager about implementing into elementary schools. The findings and conclusions of this study suggest important implications in regards to implementing STEM education in elementary schools. Many implications for practice will be used by varying populations; however, those not familiar with STEM education may have the most to benefit.

Teachers can use this information to better understand the significance and importance of presenting project-based, inquiry-based, student-centered lessons for their classrooms. Teachers must place high expectations on students and their ability to problem solve. Teachers must begin to view themselves as the facilitators of information rather than the centers of attention.

Administrators can value the research gathered in this study, because it shows the importance of integrating STEM into a school. Elementary building principals can strive to incorporate professional development opportunities to prepare teachers to become STEM teachers and to develop a better understanding of the STEM process. District-level administrators can use this information to gain insight as to what units of curriculum could be the most effective in improving academic achievement.

Most importantly, this study could have a significant impact on the future of students. Science, technology, engineering, and mathematics education is a topic that is growing in popularity and with the ever-changing world, STEM education is, moving to the forefront of procuring a successful and profitable future. Science, technology, engineering, and mathematics education is only going to continue to grow and impact the daily lives of everyone involved.

Recommendations for Future Research

This qualitative study focused on STEM education in elementary schools only. Future research on analyzing principals and teachers at the junior high and high school levels would be a great complement to this study. The perspectives from all levels of education would offer insight in the vertical alignment of curriculums. In order to truly integrate science, technology, engineering, and mathematics into classrooms, it will take a collaborative effort.

This study was limited in the number of individuals interviewed. It is further recommended research on STEM schools continues with a greater population outside the state of Missouri. This would allow varying perspectives on STEM education due to geographical location. It would also be a benefit to gain the perspectives of a larger population.

This study did not include interviews of parents of children attending STEM schools. Future studies could include interviews of parents within STEM schools to gain their insights on the benefits of attending a STEM school. The children of these parents might also be interviewed to gain the perspectives of those directly receiving a STEM education.

For this study, the researcher used strictly qualitative measures to obtain data. In the future, a quantitative approach could be taken to examine how becoming a STEM school effects student achievement on mandatory state assessments. In addition, a longer period of time would allow for the opportunity to see academic gains from the implementation of STEM. Since the introduction of STEM schools in Missouri is a fairly new concept, a study conducted in three to five years would present more data to analyze.

Summary

The concept of STEM education is a topic that is becoming increasingly popular in the education community. This qualitative study was designed to discover perceptions of elementary STEM schools in Missouri. In this study, the perceptions of leaders in professional STEM organizations, elementary STEM principals, and elementary STEM teachers were consistent with each other and all shed a positive light on elementary STEM education.

In Chapter One, a historical basis for the research was provided. The conceptual framework, the statement of the problem, and the purpose of the study were presented. The research questions to guide this study were posed. Additionally, the definitions of key terms, limitations, and assumptions were detailed. In Chapter Two, a literature review was included to generalize STEM education. The main topics of discussion were to define the term STEM, to examine why there is a push for STEM education, and to delineate the reasons behind it.

In Chapter Three, the methodology used in this qualitative study was described. An overview of the problem and purpose of the study was presented. Descriptions of the population and sample were provided, as well as the instrumentation used. Finally, the data collection and data analysis processes were detailed.

Chapter Four included the perceptions and opinions of various stakeholders involved in the STEM education community within the state of Missouri. Interviews with elementary principals and teachers in STEM schools and leaders in professional STEM organizations were analyzed. In this study, the perceptions were those of enthusiasm and passion for the field of STEM education.

The findings from the analysis of data and a summary of these findings were presented in Chapter Five. Each of the research questions was revisited and conclusions were discussed. Implications for practice were addressed, and recommendations for future research concerning STEM education were presented.

Appendix A

Principal Interview Questions

1. How do you define STEM Education?
2. When did your school become a STEM school?
   a. Briefly outline the process.
3. What are your curriculum requirements?
4. What benefits have you seen from becoming a STEM school?
5. What impact has your STEM school had on student engagement?
6. What impact has your STEM school had on student achievement?
7. What professional development did teachers receive to prepare for teaching in a STEM school?
8. What impact has STEM had on teacher attitude in regards to the implementation of STEM?
9. What have been the most observable outcomes within STEM education to date?
10. What concerns do you have about STEM education in general?

Appendix B

Teacher Interview Questions

1. How do you define STEM Education?
2. When did your school become a STEM school?
    a. Briefly outline the process.
3. What are your curriculum requirements?
4. What benefits have you seen from becoming a STEM school?
5. What impact has your STEM school had on student engagement?
6. What professional development did you receive to prepare for teaching in a STEM school? Please describe the usefulness, quantity, and the continuity of this professional development.
7. What impact has the implementation of STEM had on teacher/student attitude?
8. What have been the most observable outcomes within STEM education to date?
9. What concerns do you have about STEM education in general?

Appendix C

Professional STEM Organization Interview

1. How do you define STEM Education in elementary schools?
2. Why is elementary STEM Education important to the United States?
3. What are the challenges we as a nation face with regards to STEM Education?
4. Should there be curriculum requirements in order to become a STEM school? Why or why not?
5. What professional development should teachers receive to prepare for teaching in a STEM school?
6. What have been the most observable outcomes within STEM education to date?
7. What concerns do you have about elementary STEM education?

Appendix D

Letter of Participation

Interview

Date
Title of Person
Position
School District
Address

Dear Title, First Name and Last Name,

Thank you for participating in my research study, *The Perceptions of Elementary STEM Schools in Missouri.* I look forward to talking to you on _______(date) at ______(time) to gather your perceptions on Elementary STEM schools in Missouri public schools. I have allotted one hour to conduct our interview.

Enclosed you will find the interview questions to allow time for reflection before our interview. I have also enclosed the Informed Consent Form for your review and signature. If you agree to participate in the study, please sign the consent form.

Your participation in this study is voluntary and you may withdraw at any time. Confidentiality is assured. If you have any questions, please call [redacted] or email kk575@lionmail.lindenwood.edu. Once the study has been completed, the results will be available per your request.

Sincerely,

Kelli Alumbaugh
Doctoral Candidate
Lindenwood University

Appendix E

Lindenwood University

School of Education
209 S. Kingshighway
St. Charles, Missouri 63301

Informed Consent for Participation in Research Activities

"The Perceptions of Elementary STEM Schools in Missouri"

Principal Investigator Kelli Alumbaugh

Telephone: [redacted] E-mail: kk575@lindenwood.edu

Participant________________________________ Contact info ______________________

1. You are invited to participate in a research study conducted by Kelli Alumbaugh under the guidance of Dr. Sherry DeVore. The purpose of this research is to examine the perception of Elementary STEM Schools in Missouri.

2. a) Your participation will involve:
   - Verbally answering open-ended questions in a face-to-face or phone interview to obtain your perceptions on Elementary STEM Schools.

     I give permission for the interview to be audio recorded (participant's initials) ____.

   b) The amount of time involved in your participation will be approximately 60 minutes.

   Approximately 14 educators will be involved in this research.
   - 4 Elementary Principals
   - 8 Elementary Teachers
   - 2 Professional STEM Organization Leaders

3. There are no anticipated risks associated with this research.

4. There are no direct benefits for you participating in this study. However, your participation will contribute to the knowledge about Elementary STEM Schools.

5. Your participation is voluntary and you may choose not to participate in this research study or to withdraw your consent at any time. You may choose not to answer any questions that you do not want to answer. You will NOT be penalized in any way should you choose not to participate or to withdraw.

6. We will do everything we can to protect your privacy. As part of this effort, your identity will not be revealed in any publication or presentation that may result from this study and the information collected will remain in the possession of the investigator in a safe location.

7. If you have any questions or concerns regarding this study, or if any problems arise, you may call the Investigator, Kelli Alumbaugh ([redacted]) or the Supervising Faculty, Dr. Sherry DeVore (417-881-0009). You may also ask questions of or state concerns regarding your participation to the Lindenwood Institutional Review Board (IRB) through contacting Dr. Jann Weitzel, Vice President for Academic Affairs at 636-949-4846.

I have read this consent form and have been given the opportunity to ask questions. I will also be given a copy of this consent form for my records, upon request. I consent to my participation in the research described above.

____________________________________ ____________________________________

Participant's Signature Date Participant's Printed Name

____________________________________ ____________________________________

Signature of Principal Investigator Date Investigator Printed Name

Appendix F

Approval Letter
Institutional Review Board

LINDENWOOD

LINDENWOOD UNIVERSITY ST. CHARLES, MISSOURI

DATE:	June 12, 2015
TO:	Kelli Alumbaugh
FROM:	Lindenwood University Institutional Review Board
STUDY TITLE:	[753832-1] The Perceptions of Elementary STEM Schools in Missouri
IRB REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	June 12, 2015
EXPIRATION DATE:	June 12, 2016
REVIEW TYPE:	Expedited Review

Thank you for your submission of New Project materials for this research project. Lindenwood University Institutional Review Board has APPROVED your submission.

This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure. All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to the IRB.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the completion/amendment form for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of April 29, 2016.

Please note that all research records must be retained for a minimum of three years.

If you have any questions, please contact Megan Woods at (636) 485-9005 or mwoods1@lindenwood.edu. Please include your study title and reference number in all correspondence with this office.

If you have any questions, please send them to mwoods1@lindenwood.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Lindenwood University Institutional Review Board's records.

References

American Psychological Association. (2012). *Publication manual of the American Psychological Association* (6th ed.). Washington, DC: American Psychological Association.

Avery, Z. K., & Reeve, E. M. (2013). Developing effective professional development programs. *Journal of Technology Education*, *25*(1), 55-69.

Basham, J. D., & Marino, M. T. (2013). Understanding STEM education and supporting students though universal design for learning. *TEACHING Exceptional Children*, *45*(4), 8-15.

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education*, *12*(5), 23-37.

Bertram, V. (2014). The most important resolution: STEM education. Retrieved from http://edexcellence.net/commentary/education-gadfly-daily/flypaper/the-most-important-resolution-stem-education

Bicer, A., Navruz, B., Capraro, R., & Capraro, M. (2014). STEM schools vs. non-STEM schools: Comparing students mathematics state based test performance. *International Journal of Global Education*, *3*(3), 8-19. Retrieved from www.ijge.net/ojs/index.php/IJGE

Bluman, A. G. (2015). *Elementary statistics: A step by step process, a brief approach* (9th ed.). New York, NY: McGraw-Hill.

Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM: Current perceptions. *Technology and Engineering Teacher*, *70*(6), 5-9.

Butin, D. W. (2010). *The education dissertation: A guide for practitioner scholars.* Thousand Oaks, CA: Corwin.

California Department of Education. (2014). Science, technology, engineering and mathematics. Retrieved from http://www.cde.ca.gov/pd/ca/sc/stemintrod.asp

Carnegie Science Center. (2014). The role of STEM education in improving the tri-state region's workforce. Retrieved from http://www.carnegiesciencecenter.org/stemcenter/stemcenter-work-to-do-the-role-of-stem-education/

Chen, G. (2011). The rising popularity of STEM: A crossroads in public education or a passing trend? Retrieved from www.publicschoolreview.com/articles/408

Chesloff, J. D. (2013). STEM education must start in early childhood. *Education Week, 32*(23), 27-32.

Committee on Integrated STEM Education, National Academy of Engineering, and National Research Council. (2014). *STEM integration in K-12 education: Status prospects, and an agenda for research.* Washington DC: National Academies Press.

Connections Learning. (2015). STEM Education: Preparing students for a growing field. Retrieved from www.connectionslearning.com/libraries/PDF's/STEM_Primer_PreparingStudents

Cunningham, J. (2012). Student achievement. Retrieved from www.ncsl.org/documetns/educ.CharterSchoolStudentAchievement.pdf

Denzin, N. and Lincoln, Y. (2nd ed.) (2003). *The landscape of qualitative research: Theories and issues.* Thousand Oaks, CA: Sage Publications, Inc.

Desilver, D. (February 2, 2015). *U.S. students improving –slowly –in math and science, but still lagging internationally*. Retrieved from http://www.pewresearch.org/fact-tank/2015/02/02/u-s-students-improving-slowly-in-math-and-science-but-still-lagging-internationally/

Drew, D. E. (2011). *STEM the tide: Reforming science, technology, engineering, and math education in America.* Baltimore, MD: The John Hopkins University Press.

Dugger, W. (2011, February). *The overlooked STEM imperatives: Technology and engineering.* Paper presented at the United States Department of Educational Regional Mathematics and Science Partnerships Conferences, San Francisco, CA. Retrieved from www.iteea.org/Resources/PressRoom/2011ITEEAMSPmtg.ppt

Eberle, F. (2010). Why STEM education is important. *InTech Magazine.* Retrieved from www.isa.org/standards-and-publications

Federal Inventory of STEM Education. (2011). The federal science, technology, engineering, and mathematics (STEM) education portfolio. Retrieved from The Executive Office of the President of the United States website: http://www.whitehouse.gov/sites/default/files/microsites/ostp/costem__federal_stem_education_portfolio_report.pdf

Fioriello, P. (2014). Understanding the basics of STEM education. Retrieved from http://drpfconsults.com/understanding-the-basics-of-stem-education/

Fisher, D., Frey, N., & Pumpian, I. (2012). *How to create a culture of achievement in school and classroom.* Alexandria, VA: ASCD.

Fraenkel, J., Wallen, N., & Hyun, H. (2015). *How to design and evaluate research in education.* (9th ed.). New York, NY: McGraw-Hill.

Gay, L., Mills, G., & Airasian, P. (2011). *Educational research.* Columbus, OH: Pearson.

Gerlach, J. (2012). STEM: Defying a simple definition. *NSTA WebNews Digest.* Retrieved from http://www.nsta.org/publications/news/story

Goldston, C. (2014). How student engagement facilitates STEM interest. *PBS.org.* Retrieved from www.pbs.org/wgbn/nova/blogs/education/2014/10

Gonzalez, H., & Kuenzi, J. (2012). Science, technology, engineering, and mathematics (STEM) education: A primer. Retrieved from Congressional Research Service website: http://fas.org/sgp/crs/misc/R42642.pdf

Hanover Research. (2012). Best practices in elementary STEM programs. Retrieved from http://school.elps.k12.mi.us/ad_hoc_mms/committee_recommendation/4.pdf

Herschbach, D. (2011). The STEM initiative: Constraints and challenges. *The Journal of Stem Teacher Education, 48*(1), 96-122.

Hom, E. J. (2014). What is STEM education? Retrieved from http://www.livescience.com/43296-what-is-stem-education.html

Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. (2011). STEM: Good jobs now and for the future. Retrieved from http://www.esa.doc.gov/reports/stem-good-jobs-now-and-future

Lantz, H. B. (2009). Science, technology, engineering, and mathematics (STEM) education: What form? What function? Retrieved from http://www.currtechintegrations.com/pdf/STEMEducationArticle.pdf

Lather, P. (2006). Paradigm proliferation as a good thing to think with: Teaching research in education as a wild profusion. *International Journal of Qualitative Studies in Education*, *19*(1), 35-57.

Lynch, S. J., Han, E. M., Peters, B. E., & House, A. (2013, May). *Inclusive STEM high schools: Innovative STEM partnerships and practices to enhance opportunities for diverse students.* Presentation at the 1013 NSTS STEM Forum and Expo, St. Louis, MO.

Marzano, R. J. (2013). Ask yourself: Are students engaged. *Educational Leadership*, *70*(6), 81-82.

Meyrick, K. (2012). How STEM education improves student learning. *Meridian*, *14*(1). Retrieved from http://www.ced.ncsu.edu/meridian/index.php/meridian/article/view/6

Missouri Department of Elementary and Secondary Education. (2014). Common Core placemats. Retrieved from http://dese.mo.gov/sites/default/files/WhatDoYouKnowCommonCore.pdf

Murphy, T. (2011, August 29). STEM education—It's elementary. *U.S. News.* Retrieved from www.usnews.com/news/articles/2011/08/29/stem-education-its-elementary

Nadelson, L. S., Seifert, A., Moll, A. J., & Coats, B. (2012). I-STEM summer institute: An integrated approach to teacher professional development in STEM. *Journal of STEM Education*, *12*(2), 69-83.

National Assessment Governing Board. (2014). National Assessment of Educational Progress. National Center for Education Statistics. Retrieved from http://nces.ed.gov/nationsreportcard/

National Commission of Excellence in Education. (1983). *A nation at risk.* Retrieved from http://www2.ed.gov/pubs/NatAtRisk/index.html

National Research Council. (2014). *National science education standards.* Washington DC: The National Academies Press.

National Science Foundation Act. 42 U. S.C. § 1861 (1950)

National Science Foundation. (2014). The NSF mission. Retrieved from www.nsf.gov/nsf/nsfpubs/straplan/mission.htm

National Staff Development Council. (n.d.). *What is professional development?* Retrieved from http://aypf.org/documents/62609NSDCDefinitionofProfessionalDevelopment908.pdf

Navruz, B., Erdogan, N., Bicer, A., Capraro, R., & Capraro, M. (2014). Would a STEM school 'by any other name smell as sweet'? *International Journal of Contemporary Educational Research, 1*(2), 67-75. Retrieved from http://ijcer.net/index.php/home

Partnership for 21st Century Skills. (2009). P21 framework definitions. Retrieved from http://p21.org.storage/documents/P21_Framework_Defintions.pdf

Partnership for 21st Century Skills. (n.d.). Learning for the 21st century: A report and MILE guide for 21st century skills. Retrieved from http://www.p21.org/storage/documents/P21_Report.pdf

President's Council of Advisors on Science and Technology. (2010). Prepare and inspire: K-12 education in science, technology, engineering, and math (STEM) for America's future. Retrieved from http://www.whitehouse.gov/sites/ default/files/microsites/ostp/pcast-stemedreport.pdf

President's Council of Advisors on Science and Technology. (2014). Preparing Americans with 21st century skills. Retrieved from www.whitehouse.gov/ostp

Project Lead the Way. (n.d.). Our programs. Retrieved from https://pltw.org/

Ricks, E. D. (2012). Cultivating early STEM learners: An analysis of mastery classroom instructional practices, motivation, and mathematic achievement in young children. Retrieved from www.proquest.com/3522180

Riley, C. (2015, February 6). Nixa STEM program shines as state looks to expand. *The Springfield News-Leader*. Retrieved from http://www.news-leader.com/story/news/education/2015/02/06/nixa-stem-program-shines-state-looks-expand/23006245/

Robinson, W. (2014, September 1). Policymakers hail STEM education as a strong foundation, pushing innovation. *The Washington Post.* Retrieved from http://www.washingtonpost.com/local/education/policymakers-hail-stem-education-as-a-strong-foundation-pushing-innovation/2014/09/01/5ad9b772-2e01-11e4-bb9b-997ae96fad33_story.html

Royal, K. (2013). Benefits of STEM. Retrieved from http://connectlearningtoday.com/benefits-stem-programs/

Salinger, G., & Zuga, K. (2009). Background and history of the STEM movement. Retrieved from http://www.iteaconnect.org/Resources/PressRoom /2009/Oct/STEMGuideAdFullPageBW.pdf

Science Pioneers. (n.d.) Why STEM education is important for everyone. Retrieved from https://www.sciencepioneers.org/.../why-stem-is-important-to-everyone

Shapiro, D. (2012, March 2). Exploring STEM professional development. *NSTA WebNews Digest.* Retrieved from www.nsta.org/publications/news/story.aspx?!d-59234

STEM Smart. (2014). STEM smart brief. *Improving STEM curriculum and instruction: Engaging students and raising standards.* Retrieved from successfulstemeducation.org/resources

Student engagement. (2014). In *The glossary of education reform*. Retrieved from http://edglossary.org/student-engagement/

Taylor, P. C. & Medina, M. N. D. (2013). Educational research paradigms: From positivism to multiparadigmatic. *Meaning Centered Education*, 1. Retrieved from http//:www.meaningcented.org/educational-research-paradigms-from-positivism-to-multiparadigmatic/

Tennessee STEM Innovation Network. (2012). Retrieved from http://thetsin.org/news/2014/stem-infusing-the-elementary-classroom-part-3/

Tsupros, N., Kohler, R., & Hallinen, J. (2009). *STEM education: A project to identify the missing components*, Intermediate Unit 1 and Carnegie Mellon, PA.

Waldron, D. (2015). Top 15 benefits of a STEM education. Retrieved from http://stemjobs.com/top-15-benefits-of-a-stem-education/

Wheelcock College Aspire Institute. (2010). Strengthening STEM education in the early years. Retrieved from www.mass.gov/edu/docs/eec/research-planning/state-planning/foundationforfuturereport.pdf

The White House. (2013). Knowledge and skills for the jobs of the future. Retrieved from www.whitehouse.gov/issues/education/k-12/educate-innovate

White House Office of Science and Technology Policy. (2014). Preparing Americans with 21st century skills. Retrieved from www.whitehouse.gov.ostp

Woodruff, K. (2013). A history of STEM: Reigniting the challenge with NGSS and CCSS. Retrieved from www.us-satellite.net/STEMblog

Yednak, C. (2015). The lowdown on STEM schools. Retrieved from www.greatschools.org/gk/articles/what-is-stem-school/

Vita

Kelli M. Alumbaugh completed her undergraduate studies in physical education and athletic training while attending Missouri State University in May 2004. She furthered her education at Lindenwood University in 2009 by receiving a Masters of Arts in Educational Administration.

Kelli began her career at the Ozark R-VI School District in 2005 where she taught fifth grade physical education, as well serving as the certified athletic trainer for the high school. In 2012, she accepted the position of elementary principal at Hurley Elementary School in the Hurley R-I School District. Kelli has held this position for the past three years.

Currently, Kelli has professional affiliations with the Missouri Association of Elementary School Principals and the National Association of Elementary School Principals.