Educator Perceptions - Effects of STEM Programs on Academic Success: Qualitative Case Study

Marsha Jean Neal

Dissertation Submitted to the Doctoral Program

of the American College of Education

in partial fulfillment of the requirements for the degree of

Doctor of Education in Leadership

June 2021

Educator Perceptions - Effects of STEM Programs on Academic Success: Qualitative Case Study

Marsha Jean Neal

Approved by:

Dissertation Chair: Anthony T. Bretti, Ed.D.

Committee Member: Joshua D. Reichard, Ph.D.

Abstract

Student academic success is key to education. The problem was not all middle school students, grades 6–8, across southeastern South Carolina were performing at a level of academic readiness for the next grade level. The study filled gaps in the literature by examining participants' perceptions of science, technology, engineering, and mathematics (STEM) initiatives on academic success of middle school students. The purpose was to explore perceptions of the effectiveness STEM initiatives on student academic success at three middle schools in southeastern South Carolina. Constructivist Learning Theory was the main theoretical framework of the study, along with Zone of Proximal Development and Transformational Leadership. Research questions were based on skills learned, STEM experiences, and strategies used at each school. Fifteen participants completed a questionnaire and were interviewed. Responses were evaluated as a whole. The questionnaires were completed through SurveyMonkey, while the interviews were completed over the phone. Responses were transcribed, and thematic analysis was used to identify six themes in the data: academic achievement, how critical thinking was fostered, long-term impact for students, implementation strategies, challenges in implementation, and the needs of teachers to implement initiatives. Ninety-three percent of the participants perceived STEM benefits all students by fostering critical thinking and problem-solving skills and provided real-world situations in the classroom. Recommendations were made for state and district education agencies, school principals, and college teacher preparation programs.

Keywords: STEM, STEM education, perceptions of STEM, middle schools, best practices, constructivism learning theory, transformational leadership

Dedication

I would like to dedicate the dissertation to Mrs. Anita Milosovic for providing me with a love of education in the fifth grade. By the age of nine, I knew I wanted to be a teacher and my 5th-grade teacher was my inspiration to go into teaching. Fifth grade was the first year a teacher motivated me, made me love school, and encouraged me to excel.

> The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires.

—William Arthur Ward

Acknowledgments

Words alone cannot express my appreciation to the people who contributed to my success. I would like to express my thankfulness to the following individuals:

I would like to express my deepest gratitude to my dissertation chair, Dr. Anthony Bretti, for his continued support during my Ed.D. study and research, for his patience, detailed feedback, motivation, and incredible knowledge. I could not have completed the dissertation without his help. I too would like to thank my dissertation committee member, Dr. Joshua D. Reichard, for his feedback and support during the process.

I would like to thank the following subject matter experts, who field-tested my research questions and provided me with feedback: Dr. Jennifer L. Albert (Director, The STEM Center of Excellence), Dr. Andrea Possehl (retired educator), Stephanie Creger (Education Coordinator, Charleston Gaillard Center), Cate Mahoney-Buesing (Science Instructional Specialist, Charleston County School District), Dr. Alice Jones (retired public-school administrator).

I would like to thank my parents, Glen and Karen Neal, for being there for me and with me throughout the entire process. My parents listened to me when I complained, when I was overjoyed, and comforted me over the phone when I cried and talked me through the few times when I wanted to give up. I could not have gotten through my dissertation without your support.

To my sister, Nancy, and brother, Mark, thanks for supporting me and being interested in my research and how my dissertation was coming along.

To my close friends, Joan, Amanda, Larry, and Shawana, who encouraged me along the way and never let me get down or overwhelmed. To all the educators who participated in the study, a huge thank you!

Table of Contents

List of Tables

List of Figures

Figure

Chapter 1

Science, technology, engineering, and mathematics (STEM) has been the basis for breakthroughs, technological innovations, and inventions throughout American history (National Science & Technology Council, 2018). STEM education is an interdisciplinary approach to learning which ties rigorous academic concepts with real-world lessons (Bess, 2019). Students apply STEM in contexts that connect school, community, work, and global enterprise (Bess, 2019).

Believed to be vital in promoting innovation, efficiency, and general economic growth, STEM education is perceived as crucial throughout many countries as it is believed to be vital in promoting innovation, efficiency, and general economic growth (English, 2017). Mounting global attention has focused on STEM initiatives because these skills have been in higher demand, not only in STEM careers but in various other occupations (English, 2017).

Students are the future workforce (Mand Labs, 2020). Students ought to be exposed to STEM to be fully prepared and qualified for future STEM vacancies (Mand Labs, 2020). Studies have shown South Carolina ranked 44th of the 50 states in education (WLTX, 2020). The case study could provide insights to other administrators, based on the perceptions of educators who were part of a school that implemented some sort of STEM initiative.

Best practices for effective STEM education include the integration of mathematics and science (Margot & Kettler, 2019). By providing integrated teaching and STEM career exploration, eighth grade students were encouraged to succeed in school and consider STEM-related careers in the future (Kier & Blanchard, 2020). The potential benefits of further study allow other schools to see the advantages of implementing STEM initiatives. Major sections of Chapter 1 consist of the background of the problem, statement of the problem, the purpose of the study, the significance of the study, research questions, theoretical framework, definitions of terms, assumptions, scope and delimitations, limitations, and chapter summary.

Background of the Problem

The background of the research problem was focused on the idea of whether or not South Carolina was to be pertinent in the workforce of the future, implementing quality STEM education in middle school was imperative (Bicer et al., 2015). The problem focused on how vital teaching STEM is in grades K–12. By developing interest, students were encouraged to succeed in school and pursue STEM-related careers (Bicer et al., 2015).

The first person who introduced and supported the notion of the ineffectiveness of teaching with the traditional lecture style was Dr. Donald Bligh (Fendos, 2018). Research showed the sooner educators tapped into children's abilities and encouraged their wonders about the world by starting a foundation for STEM education, the more successful they were later in life (Mand Labs, 2020). Empirical evidence showed the United States began to get away from lecture-based education to support a more interactive, student-centered education (Fendos, 2018).

No matter where students live, their academic achievement, or their social background, students should have access to STEM-based instruction at school (Bicer et al., 2015). Traversing the current STEM plans was challenging for states and schools but suggesting ways to advance STEM education was even more problematic (English, 2017). As integrated disciplines, STEM enhances the processes through which humans navigate life by expanding how people interact with each other, the approach by which people live life, and the different ways in which people find significance in the world (Johnson et al., 2018).

According to the Nation's Report Card (as cited in Newman et al., 2015), approximately three-fourths of eighth-graders in the United States in 2012 demonstrated a basic knowledge of mathematics. Only about one-third were performing at proficient or grade level on standardized exams. In 2017, two-fifths of the U.S. fourth-grade students who attended public schools scored at or above the proficient level in math, and one-third of eighth-graders did the same in public schools (National Assessment of Educational Progress [NAEP], 2017).

A gap existed in the research. Little has been studied related to STEM education in middle schools, with most of the research being conducted in grades 9–12 (Blotnicky et al., 2018). Few studies have investigated the perceptions of the effectiveness of STEM initiatives on academic success in middle school (English, 2016).

Statement of the Problem

The problem was not all middle school students, grades 6–8, across southeastern South Carolina, performed at a level of academic readiness for the next grade level. According to the results of South Carolina standardized tests from 2019, students who attended a school with STEM initiatives were more likely to score at a level of readiness for the next grade level (South Carolina Department of Education [SCDE], 2019b). Approximately 290 schools in South Carolina serve middle school students, but fewer than 60 schools had STEM initiatives or programs (Carolina School Hub, 2020).

A 15-year meta-analysis on the advantages of hands-on learning, which included 57 studies, 13,000 students, and 1,000 classrooms, showed students who participated in activity-based curriculum performed up to 20% higher than students who used traditional or textbook curriculum (Mand Labs, 2020). Few studies have investigated the perceptions of the effectiveness of STEM programs on student academic success (English, 2016). Examples of ways to teach STEM concepts in schools were the focus of most articles written. How educators felt STEM education impacted academic achievement, especially across the board and integrating all subject areas, had not been a focus of research. Many teachers believed themselves incompetent to teach STEM (Yildirim & Türk, 2018).

Purpose of the Study

The goal of the study was to discover and understand how school educators perceived the effectiveness of STEM initiatives on student academic success. The purpose was to explore perceptions of the effectiveness STEM initiatives on student academic success at three middle schools in southeastern South Carolina. In-depth understanding of the perceptions of the educators involved in the study was needed.

As a form of research methodology, a qualitative case study allowed for a description of the perceptions of educators to gain subjective and pure perceptions of the real-world experiences of the participants with accuracy (Koopman, 2017). The case study explored the perceptions of educators of the effectiveness of STEM initiatives on student academic success in middle schools in southeastern South Carolina. The rationale for using the research design of a case study was to explain how and why STEM initiatives were effective on student academic success, based on the perceptions of educators.

The goal of the study was to explore how participants felt the STEM initiatives impacted student academic success. Study participants were educators from three middle schools in southeastern South Carolina. All three middle schools provided STEM initiatives for students in the school. Participants from three middle schools in three districts were used, along with teachers from different grade levels who taught different subject areas and administrators and instructional coaches.

Significance of the Study

By expanding awareness of the various ways to implement STEM initiatives in middle schools, the study expanded an understanding of teaching the importance of STEM education and the effectiveness of STEM initiatives on student academic success. Studies showed students exposed to STEM education at an early grade level performed better in math and science later on in school (Mand Labs, 2020). The research could expand the perceptions of educators of the impact of STEM education on middle school students' academic success (Neubauer et al., 2019).

High-quality learning environments nurture a lifelong interest in STEM (Mand Labs, 2020). STEM education provides students with a structure to encourage students' natural disposition to question, build, and explore. Students' natural disposition to question, build, and explore validates why STEM education ought to be introduced in all elementary schools and offered in all middle schools for all students across the United States (Mand Labs, 2020).

As less than 25% of public middle schools in South Carolina had STEM initiatives, the study results may lead to curriculum policy changes and improved professional practices (Carolina School Hub, 2020). Fendos (2018) discussed the importance of inquiry-based learning through STEM education. By describing STEM initiatives through the perceptions of educators who were involved in the initiatives daily, other school administrators may decide to start STEM initiatives (Stahnke et al., 2016).

By implementing STEM initiatives in middle schools, teachers' professional practice improved (Johnson et al., 2018). STEM teachers need multidisciplinary knowledge (El Nagdi et al., 2018). There is a unique set of pedagogical applications which help fulfill a strong STEM integration curriculum (OwlGen, 2020).

Social changes impact the way humans interact, and the different relationships alter cultural and social organizations over time, providing weighty results for society (Dunfey, 2019).

The responsibility of education as an agent of social transformation is highly accepted (OwlGen, 2020). Schools as institutions have improved over time due to many social developments throughout history (Dunfey, 2019).

In an attempt to maintain a lead in most fields in the globalized world, the United States needed to implement high-quality STEM education in schools but were slow to do so (El Nagdi et al., 2018). Reports showed U.S. students had been falling behind in performance on international tests, particularly in science and mathematics, since 1985 (El Nagdi et al., 2018). Policymakers were calling for integrated considerations to STEM education in grades K–12. Implications of the study informed both schools and policymakers to implement STEM education in most, if not all, schools across the United States.

Research Questions

Exploring the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina was the purpose of the case study. The following research questions guided the study:

Research Question 1: What did middle school educators feel were the benefits students received from participating in STEM programs based on the results of the standardized tests for the state?

Research Question 2: How did educators describe the experiences of students while participating in STEM initiatives?

Research Question 3: How did educators perceive strategies of STEM education to be effective in helping middle school students achieve academic success?

Theoretical Framework

Many changes throughout the world have led to a shift in students' capabilities (Tan et al., 2017). The shift created what scholars called 21st-century learners (Tan et al., 2017). Students went from solely obtaining knowledge to needing to have a mastery of the implementation of 21st-century skills (Barak, 2017). Key elements of the theoretical framework were constructivism, zone of proximal development, and transformational leadership. Constructivism is centered on a hands-on approach to learning, as is STEM education (Nugroho & Wulandari, 2017). Zone of proximal development is the theory students learn from each other through social engagement and culture (Sharkins et al., 2017). Transformational leaders wanted positive changes to occur in schools and supported innovative ideas (Kouni et al., 2018). According to Lamm et al. (2016) leadership in the school needed to accept a STEM program to significantly affect a school.

Constructivism incorporates an inquiry-based learning style, consisting of project-based learning, which makes the classroom student-focused (TES Editorial, 2018). For students to succeed in school, leaders needed to make sure the focus was on the students (Young et al., 2017). When students were allowed to take an active role in learning, STEM education allowed students to become excited about learning and STEM careers (Kouni et al., 2018).

Project-based learning and the engineering design process are critical components of STEM education, built on the constructivist learning theory (Johnson et al., 2018). The skills learned create scientifically literate students (Next Generation Science Standards, 2020). The engineering design process has a similar progression of steps engineers use in real life (National Aeronautics and Space Administration, 2018). The steps to a successful operation were to ask questions, imagine different solutions, plan two or three designs, create and test a model, and improve the model based on the testing step results (National Aeronautics and Space Administration, 2018).

The phenomenon of the study was grounded on the participants' perceptions, which allowed for a comprehension of the participants' meaning regarding personal experiences with STEM implementation (Clark & Vealé, 2018). The research questions of the study helped describe perceptions of the effectiveness of STEM initiatives on student academic success on middle school students. Open-ended questions guided the questionnaire responses, and the interview responses allowed the educators to describe the importance of hands-on learning through STEM education (Creswell & Poth, 2018). For leaders to see the full potential of the STEM program for students, schools needed to fully implement STEM education (Iqbal et al., 2016).

Constructivism learning theory was the main theoretical framework used, along with zone of proximal development and transformational leadership. Constructivism was chosen based on the applicability to STEM education (Huet, 2018). STEM education and constructivism are active learning approaches, as is the zone of proximal development (Barak, 2017). A second facet within the theoretical framework was transformational leadership (Lamm et al., 2016). Transformational leadership allowed for an acceptance of STEM initiatives, as leadership positively affected education and staff development (Lamm et al., 2016).

Definitions of Terms

The following definitions in describing the qualitative case study are needed. A clear identifiable definition of each word or phrase developed an understanding of the concepts described.

College and Career Readiness. College and Career Readiness is a classification for a student who is ready for college, careers, life, and the future is college and career ready (Achieve, 2020).

Exceeded Expectations on Standardized Test. When a student scores exceeded expectations on the state test, the indication is the student is well prepared for the next grade level and is college and career ready (SCDE, 2019a).

Met Expectations on Standardized Test. When a student scores met expectations on the state test, the student is prepared for the next grade level and on track for college and career readiness (SCDE, 2019a).

Proficient Level of Academic Readiness. When a student scores at the proficient level on an assessment, the student demonstrated strong academic performance and competency in the subject matter (NAEP, 2020).

Project-Based Learning. Project-based learning is a teaching method in which students learn by being actively engaged in real-world and interest-based projects (Buck Institute for Education, 2020).

Raw Score. A raw score is an unaltered or untransformed score; how many items were answered correctly on a test (Klein, 2019).

Related Arts **.** Nonacademic classes from which students choose (e.g., band, chorus, art, Spanish, engineering, physical education) (South Carolina Department of Education, 2021).

Science, Technology, Engineering, and Mathematics (STEM) Education. STEM education is an interdisciplinary approach to learning in which rigorous academic concepts are coupled with real-world lessons as students apply STEM in contexts which make connections between school, community, work, and the global enterprise (Bess, 2019).

Transformational Leadership **.** A leadership style in which the leader encourages, motivates, and inspires employees to be innovative and create a change which can help develop and form the future success of the company (White, 2018).

Assumptions

Assumptions in research studies are beyond one's control but were still needed to ensure the credibility of the study (Wolgemuth et al., 2017). Assumptions were believed to be correct for a specific purpose, which allowed the research study to produce valid results (Theofanidis & Fountouki, 2018). The section includes a description of the assumptions used in the study.

The first assumption was the educators completing the questionnaire and interview questions had STEM education experiences. All three schools chosen for the research had STEM initiatives. To be eligible for study inclusion, participants must have had at least three years of teaching experience, worked at the present school site for at least two years, had an understanding of the STEM initiatives at the school, had direct knowledge or experience of STEM students and could explain and discuss student academic success in the classroom. Use of a purposive sample that met these inclusion criteria confirmed the participants had similar experiences within the study.

Another assumption in the study was the philosophical assumption which states reality happens by individuals interacting within their social world (Wolgemuth et al., 2017). The experiences of the participants were described to give meaning to their perceptions through the expression of answers (Horrigan-Kelly et al., 2016). The accepted assumption made in the open-ended questionnaires and interview questions was participants would give authentic responses (Theofanidis & Fountouki, 2018). The experiences about the effectiveness STEM education had on student academic success were described through the lenses of the experiences of the participants (Horrigan-Kelly et al., 2016).

The idea that STEM education is essential and vital in education was the third assumption in the study. The importance of STEM education grew over the years (Johnson et al., 2018).

Since 2015, more schools have realized the importance and have started to implement STEM initiatives (Johnson et al., 2018). Without the assumption of the future importance of STEM education, the study would not have been necessary.

Scope and Delimitations

Limitations set in place in a study were the scope and delimitations (Theofanidis & Fountouki, 2018). Several scope and delimitation factors were applied in the study. The initial factor was the choice of the research problem. The variable of interest and aspiration to have more students achieve academic success through STEM initiatives across South Carolina was the focus of the study.

The use of purposive sampling for participant selection was a delimitating factor. In order to take part in the research study, participants had to meet the inclusion criteria. In a case study, the number of participants is dependent on the saturation of the information (Creswell & Poth, 2018). This study involved 15 purposefully selected participants. Saturation was used as a criterion to discontinue data collection. The saturation of data occurs at the point when new data does not add any new information (Saunders et al., 2018).

Three research questions guided the study. A questionnaire consisting of 10 open-ended questions, and an interview consisting of 10 questions were created based on the variable of interest. Five subject-matter experts field-tested the questions for the questionnaire and interview. Qualitative questions helped to gain an understanding of each person's point of view.

Limitations

Restrictions concerning research design and methodology are limitations of a study (Theofanidis & Fountouki, 2018). The limitations of the research study are beyond one's control (Theofanidis & Fountouki, 2018). The study had several potential limitations. The participants' number of employment years at the school was the first limitation. Participants needed to have enough teaching experience and time served at the present school site to make reliable inferences and observations (Creswell & Poth, 2018). The limitation excluded some teachers at the schools from participating in the study as some teachers did not have at least two years of experience at the school site. Participants needed to have experienced the STEM initiatives phenomenon at the school site long enough to understand the phenomenon (van Manen, 2014). Participants also had to have had an understanding of the STEM initiatives at the school, direct knowledge or experience with STEM students, and could explain and discuss student academic success in the classroom.

Another limitation of the study was the methodology chosen, which was a case study. There could not have been a complete replication of the study for verification purposes due to the chosen methodology. The participants' viewpoints and perceptions at certain schools were the basis of the study (Anczyk et al., 2019). The study recorded the perceptions of 15 educators from three specific middle schools; therefore, the results could not be generalized to the larger population.

Chapter Summary

The background of the research problem was focused on the idea that if South Carolina were to be relevant in the workforce, quality STEM education was imperative (Bicer et al., 2015). The problem was not all middle school students across southeastern South Carolina performed at a level of academic readiness for the next grade level. According to South Carolina standardized tests, students who attended a school with STEM initiatives were more likely to score at the level of proficiency (SCDE, 2019b).

The purpose of the case study was to explore the perceptions of the effectiveness of

STEM initiatives on student academic success at three middle schools in southeastern South Carolina. The study was significant due to the lack of research conducted on the perceptions of educators on the effectiveness of STEM initiatives on student academic success. The theoretical framework of the study was a combination of constructivism, zone of proximal development, and transformational leadership, which guided and supported the study. Three assumptions were applied to the study and were needed to ensure the relevance of the study.

The next chapter consists of the literature search strategy and theoretical framework. Chapter 2 includes a synthesis of the literature on academic problems in education and the significance of STEM education. Best practices in education, the impact of STEM education implementation, and different perceptions of STEM education are discussed. The future of STEM education and gaps in the literature are also a part of Chapter 2. The chapter concludes with a summary.

Chapter 2: Literature Review

The problem was not all middle school students, grades 6–8, performed at a level of academic readiness for the next grade level across southeastern South Carolina. According to South Carolina standardized tests, students who attended a school with STEM initiatives were more likely to score at the level of proficiency (SCDE, 2019b). The background of the research problem was focused on the importance of the future workforce of South Carolina. If South Carolina were to be relevant in the workforce, quality STEM education in school was imperative (Bicer et al., 2015). The purpose of the study was to explore the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina.

When best practices are used in education, students reap the benefits (Bicer et al., 2015). Best practices for effective education included integrating mathematics and science for teaching STEM (Margot & Kettler, 2019). Teaching STEM in grades K–12 is vital to develop an interest in students in one of the STEM-related subjects (Bicer et al., 2015).

Through teaching integrated STEM in grades K–12, students are encouraged to succeed in school and consider a STEM-related career in the future (Kier & Blanchard, 2020). STEM schools are necessary for students, no matter where students live, the academic achievement or social background of the student (Bicer et al., 2015). A gap existed in literature as little research had been conducted on STEM education in middle schools, with most of the research being conducted in grades 9 – 12 (Blotnicky et al., 2018).

The literature search strategy and theoretical framework begin Chapter 2. The research literature review consists of explorations of the academic problems in education, the significance of STEM education, best practices in education, and STEM education. The different perceptions of STEM education are then discussed, along with the future of STEM education. The chapter closes by describing gaps in the literature as well as a chapter summary.

Literature Search Strategy

The research reviewed for the study was obtained from peer-reviewed journals, books, articles, and primary sources. The literature search strategy section presented the tools and strategies used to search for, find, and document articles pertinent to studying the implementation and perceptions of STEM education. Identified search engines and databases used in the study and an included list of the keywords utilized in the literature search are in the section.

The literature included in the seven major sections of the literature review was from various resources accessed through the American College of Education (ACE) library. The library resource allowed for searches into peer-reviewed articles and educationally sound articles and research studies related to the terms relevant to the research study. Furthermore, resources were found using Google Scholar when supplemental articles or corroboration were required, or when full texts were unavailable through the ACE library. Books by experts in the field of theory and STEM education were purchased or borrowed.

Key words searched during the study were exclusive to the two primary concepts covered throughout the literature review: the conceptual framework and the research literature review. The conceptual framework required searches using the following terms: *constructivism*, *hands-on learning*, *project-based learning*, *Von Glasersfeld, Bloom's taxonomy*, *constructivism learning theory*, *experiential learning*, *David Kolb*, *Lev Vygotsky*, *zone of proximal development (ZPD)*, and *conceptual framework*. The literature review required searches using the following terms: *science, technology, engineering, and mathematics; science, technology, engineering, and* *mathematics education*; *integrated curriculum; student perceptions*; *teacher perceptions*; *education*; *middle school*; *motivation*; *multidisciplinary*; *importance of science, technology, engineering, and mathematics education*; *effect of science, technology, engineering, and mathematics education*; *teaching*; *opinions of science, technology, engineering, and mathematics education*; *best practices in education*; and *science, technology, engineering, and mathematics strategies*.

Theoretical Framework

Many changes throughout the world have led to a shift in students' capabilities (Tan et al., 2017). This shift has created what scholars call 21st-century learners (Tan et al., 2017). Students have gone from solely obtaining knowledge to needing to have a mastery of 21^{st}-century skills (Barak, 2017). The constructivist learning theory was one of the influential philosophies in education for the 21st century (Krahenbuhl, 2016). Leadership in the school must offer STEM programs to significantly impact student learning (Lamm et al., 2016).

Constructivist Learning Theory

The study was based upon the constructivist learning theory (Akron & Aşiroğlu, 2018). The foundation of constructivism is the idea students learn by doing and actively constructing knowledge rather than being told the information (Barak, 2017). One of the main approaches in education is constructivism. Constructivism is student-centered and STEM education is built upon student-centered learning (Huet, 2018). Putting the child at the center of the learning while incorporating inquiry-based learning and completion of projects are the foundations of constructivism (TES Editorial, 2018).

State and national guidelines in science changed the teaching methods and practices in the classroom (Barak, 2017). The focus of education is on the constructivist learning theory, which allows educators to aid students in deep learning and abstract thinking (Barak, 2017). For students to succeed in school, the focus needs to be on the students (Kwon et al., 2021). The concept around constructivism consists of learning as an active and constructive development and is focused on learning and teaching through experiences (Nugroho & Wulandari, 2017).

In a classroom, based on the constructivist learning theory, students discuss open-ended questions and find answers and explanations to real-world problems (Sharkins et al., 2017). Jean Piaget was a Swiss psychologist known for his constructivist theory of learning (Smith, 2017). The beliefs of Piaget were around the idea in which students' interactions with the world actively constructed knowledge through engaging in hands-on learning and exploration (Csizmadia et al., 2019). Under the constructivist theory, the educational discussion focuses on student-centered education (Krahenbuhl, 2016).

Piaget considered intellectual development a method of adaptation or adjustment to the world, which happened through assimilation, accommodation, and equilibration (McLeod, 2018a). Assimilation uses existing knowledge to cope with new situations and accommodation occurred when the current knowledge did not work and needed to be changed to deal with the new situation. Equilibration keeps the learning going (McLeod, 2018a). Students found solutions to problems in constructivist classrooms, worked at one's own pace, and justified thought processes related to how the answer was reached (Sharkins et al., 2017).

A German philosopher, Ernst von Glasersfeld believed learners should take an active learning role (Riegler, 2018). The belief of Ernst von Glasersfeld was students needed to extend the knowledge already possessed and experienced in obtaining the new knowledge (Huet, 2018). The center of constructivism is on a meaning-making procedure in which students make distinct understandings of experiences, thereby constructing meaning in each person's mind

(Krahenbuhl, 2016). Many philosophers and psychologists have had similar theories to constructivism throughout the years discussing education (Clark, 2018). Although the theories were slightly different, the overall concepts were similar, as in the constructivist learning theory and the zone of proximal development (ZPD) theory (Clark, 2018).

Zone of Proximal Development

Lev Vygotsky was a Russian psychologist whose sociocultural approach led to the concept of the ZPD (McLeod, 2018b). The primary basis in constructivism was Vygotsky's social development theory (Clark, 2018). Vygotsky believed the ZPD was through social engagement and culture, which allows for a scaffolding approach in which students learn from each other (Sharkins et al., 2017). The social development theory of ZPD indicates social connections come before cognitive reasoning and assists students in discovering more profound meaning in new information (Sharkins et al., 2017).

Project-based learning is a teaching method based on Vygotsky's ZPD (Clark, 2018). Research suggests students learned not only content but thinking strategies by learning through the personal involvement of solving problems (Moallen & Igoe, 2018). Through project-based learning, students obtain new knowledge and skills by solving an authentic problem, question, or challenge (DeMink-Carthew & Olofson, 2020).

Teachers play an essential role in the idea of Vygotsky's approach to ZPD through scaffolding (Clark, 2018). Project-based learning is a teaching strategy that emphasizes learning through scaffolding (Jamaluddin et al., 2019). Vygotsky believed scaffolding during project-based learning allowed for distinct stages of thinking, observing, and analyzing demonstrated by students (Sharkins et al., 2017). Proper leadership plays an integral role in education (Jamaluddin et al., 2019).

Transformational Leadership

For STEM to have the most significant impact in a school, the leadership of the school needed to accept the program (Lamm et al., 2016). According to Kouni et al. (2018), international research showed when transformational leadership was applied effectively in schools, there was a positive effect on the conditions in the school. Supporting STEM initiatives equates to supporting the entire school (Chiu et al., 2015). Transformational leadership positively impacted teachers' behavior and internal states, which influenced overall job satisfaction (Iqbal et al., 2016). Job satisfaction of a teacher affected the lives of others, especially the students, and a strong positive correlation existed between job satisfaction and student performance and progress (Iqbal et al., 2016).

The amount of satisfaction a teacher had within the profession influenced how the teacher carried out the educational role and duties, reflected on the quality of the education provided to students (Lamm et al., 2016). Most teachers believed professional growth was based on transformational leadership in the educational setting (Kouni et al., 2018). Because transformational leadership is about relationships, the leadership generates satisfactory progress (Iqbal et al., 2016). Teachers reported the individuals who supported transformational leadership led to the most significant level of professional development, along with a high level of motivation (Kouni et al., 2018).

A critical factor for solid student and teacher performance and student achievement was school leadership (Anderson, 2017). Transformational leadership positively forecasted a commitment to change within a school (Lamm et al., 2016). The leader's character was a factor in the motivation of workers' creativity (Zhang et al., 2018). The style of leadership which had the power to transform approaches, beliefs, and performances of workers to a level of motivation to achieve the highest level of achievement and performance imaginable was transformational leadership (Anderson, 2017). Transformational leaders brought out the best in workers as the leadership focused on innovations, reform, and change and revealed the finest in teams to come together and problem-solve (Lamm et al., 2016).

Research Literature Review

The study addressed gaps in understanding (Creswell & Poth, 2018) how perceptions of the effectiveness of STEM initiatives impacted the academic success of the students. The research questions of the study were developed through the lens of the theoretical framework and a result of the lack of available research documenting perceptions of the effectiveness of STEM initiatives on student success in middle schools (Office of Innovation and Improvement, 2016). The research design of the study fits the context of understanding the perceptions of the effectiveness of STEM initiatives on student success at the middle school level.

Academic Problems in Education

STEM education has been a critical issue inside and outside of schools and has influenced student achievement in many different ways (Han et al., 2015). Studies have shown over half of the students in the United States were not proficient in mathematics and science (Bicer et al., 2015). The same studies showed students in the United States did not perform as well as students in other developed countries, like Singapore (Bicer et al., 2015). According to the 2015 Programme for International Student Assessment (PISA), students in the United States ranked 38th out of 71 countries in math and science (Desilver, 2015). The Trends in International Mathematics and Science Study (TIMSS) tested students every four years in grades four and eight, since 1995 (Desilver, 2015). The study showed in 2015, 10 countries out of 48 had statistically higher average scores in math for fourth graders in the United States while seven countries had higher average scores than fourth-graders in science and eighth-graders in math and science in the U.S. (Desilver, 2015).

Other countries exceeded the United States in STEM-related bachelor's degrees, with only 33% of students in the United States studying a STEM-related field, compared to approximately 63% of students in Japan (Newman et al., 2015). Across the United States, students were falling behind other industrialized countries in STEM participation and performance (Congressional Research Service, 2018).

Public schools were created for all students in the United States to have the same access to quality education, but in the 21st century, not all schools offered the same type of education (Bottia et al., 2018). What college or university a student attended, or whether they decided to attend college, depended on the qualifications and courses offered by their previous middle and high schools (Thiele et al., 2016). Not all public schools across the United States provided the same curriculum or the same opportunities for students, especially when looking at low-income families compared to wealthy families (Bottia et al., 2018).

History of the Nation's Report Card (United States)

Some believed the nation's primary way to survive was if the people were appropriately educated (Bottia et al., 2018). NAEP test scores were released as the Nation's Report Card and measured what students in the United States knew and could do in different subject areas in grades 4, 8, and 12 (NAEP, 2020). Brown (2019) revealed the concept of a national assessment, which began with Francis Keppel in 1964, then-U.S. Commissioner of Education. Keppel realized there was a need for a national assessment to provide data regarding students' knowledge, skills, and abilities (NAEP, 2020). The same year, 1964, the formation of the

Exploratory Committee for the Assessment Progress of Education occurred. In 1969, the successful administration of the NAEP test happened for the first time (Brown, 2019).

Students across the United States take the NAEP test every year in mathematics and reading and the state assessment is required by all states (NAEP, 2020). The NAEP (2018) was different from the state assessment. States tested grade-level content based on the standards of the individual state. The NAEP test, which was the same across states, was given in all states in the U.S. to provide a standard evaluation of achievement (U.S. Department of Education [USDE], 2015).

According to the USDE (2015), there were three levels of scoring for student achievement. Basic indicated the student had partially mastered prerequisite knowledge and skills necessary to be proficient at the current grade level (USDE, 2015). Proficient indicated the student had a solid academic ability for the grade level and had demonstrated mastery in the subject area (USDE, 2015). The highest level, advanced, indicated the student was above grade level in performance (USDE, 2015).

Mathematics and Reading Scores

For the Nation's Report Card, the mathematics and reading results were available yearly for national, state, and district jurisdictions (National Assessment Governing Board, 2019). Newman et al. (2015) reported, according to the Nation's Report Card, approximately 73% of eighth-graders in the United States in 2012 demonstrated a basic knowledge of mathematics, and only about 35% were performing at the proficient level. When the scores were released, South Carolina ranked 41st out of 50 for mathematics and reading, with only 26% of eighth-grade students in mathematics and 28% of eighth-grade students in reading scoring at the proficient level (Selbe, 2016). In 2015, 40% of the U.S. fourth-grade students and 33% of the eighth-graders who attended public schools scored at or above the proficient level in math in public schools (NAEP, 2017).

The federal government announced the scores in reading and mathematics for students in grades 4 and 8 (National Assessment Governing Board, 2019). There were many changes in the scores in rankings in 2017 (Chingos et al., 2019). Of the five states which improved and moved up the rankings the most, four were in the South, with South Carolina moving up by 56 points (National Assessment Governing Board, 2019). When the scores were released, states were ranked based on the mean percentage of students in grades 4 and 8 who scored proficient or higher on the mathematics and reading assessment (Selbe, 2016).

Raw scores were adjusted for the following factors: age, race or ethnicity, special education status, English language learner status, and free and reduced-price lunch eligibility (Blagg et al., 2020). After the adjustments for eighth-grade mathematics, South Carolina ranked 19th, up from 26th two years earlier (USDE, 2019). In reading, South Carolina ranked 15th, up from 32nd two years earlier (USDE, 2019). For eighth-grade mathematics, before adjusting scores for the factors mentioned earlier, South Carolina ranked 39th of the 50 states (USDE, 2019). Overall, for the United States, 34% of eighth-grade students scored proficient or higher in mathematics and reading (USDE, 2019).

In South Carolina, middle school students took the South Carolina College- and Career-Ready Assessments for English language arts (ELA) and mathematics annually (SCDE, 2019b). With the South Carolina College- and Career-Ready Assessments, test questions aligned with the South Carolina state standards in mathematics and ELA (SCDE, 2019b). The standards guided the teaching and expectations of what students learned each year in mathematics and ELA

(SCDE, 2019b). An average of 38.6% of middle school students met or exceeded expectations in mathematics and ELA (SCDE, 2019b).

For sixth-graders, 43.9% met or exceeded expectations in mathematics, and 41% met or exceeded expectations in ELA (SCDE, 2019b). In seventh grade, 35.3% of the students met or exceeded expectations in mathematics, and 44% met or exceeded expectations in ELA (SCDE, 2019b). With the eighth-grade students, 36.6% met or exceeded expectations in mathematics, and 44.6% met or exceeded expectations in ELA (SCDE, 2019b).

For some schools with a school-wide STEM initiative, the South Carolina College- and Career-Ready Assessments scores looked different than the scores of the state as a whole (SCDE, 2019b). Test scores for one middle school in southeastern South Carolina without a STEM program showed 18.5% of the students met or exceeded expectations in mathematics, and 22.8% met or exceeded expectations in ELA. At another middle school in southeastern South Carolina with a school-wide STEM, 47% of the students met or exceeded expectations in mathematics, and 44.3% met or exceeded expectations in ELA. At a third middle school in southeastern South Carolina with a school-wide STEM program, 41.4% of the students met or exceeded expectations in mathematics, and 56.9% met or exceeded expectations in ELA.

Science Scores

Unlike the mathematics and reading NAEP tests, the science results were only available every four years from the national and district jurisdictions. However, the availability by state jurisdiction varied by year (NAEP, 2020). Across the United States, the science scores for most student groups in grade 8 were higher than six years prior (National Assessment Governing Board, 2015).

Compared to six years prior, scores in physical science, life science, and Earth and space sciences were higher for students in grade 8 (National Assessment Governing Board, 2015). Overall, for the United States, 34% of eighth-grade students scored proficient or higher in science (USDE, 2019). Even though less than 40% of eighth-graders scored proficient or higher, there was still an increase from years prior (USDE, 2019).

For the state assessments in South Carolina, middle school students took the South Carolina Palmetto Assessment of State Standards (SCPASS) for science in grade 6 annually (SCDE, 2019b). With the SCPASS, test questions aligned with the South Carolina state standards in science (SCDE, 2019b). The standards guided the teaching and the students' learning expectations each year in science (SCDE, 2019b).

In years past, across South Carolina, sixth- and eighth-grade students took the South Carolina state assessment in science (SCDE, 2019b). Of all students tested in sixth and eighth grades, 47.3% met or exceeded expectations in science (SCDE, 2019b). Students in seventh grade did not take the SCPASS for science (SCDE, 2019b).

For some schools with a STEM school initiative, the scores for the SCPASS in science were better than the state average (SCDE, 2019b). At one middle school in southeastern South Carolina, test scores showed 26.9% of sixth- and eighth-graders met or exceeded expectations in science. At another middle school in southeastern South Carolina with a school-wide STEM initiative, 52.5% of the students met or exceeded expectations in science. At a third middle school in southeastern South Carolina with a school-wide STEM initiative, 49.5% of the students met or exceeded expectations in science.

Trends and Accountability

Since the mid-1990s, school accountability systems had become a central focus of education reform in the United States (Dizon-Ross, 2020). When looking at U.S. test scores holistically from 2005 to 2019, little to no progress had been made (Chingos et al., 2019). Since 2009, mathematics scores of eighth-graders dropped by one point, and reading scores remained the same for the entire decade (Chingos et al., 2019). In New York City, low-performing schools receiving a failing grade for one school year improved performance the following year (Dizon-Ross, 2020).

National statistics revealed contrary ideas in terms of student academic achievement. A worrisome trend across the United States indicated scores dropped among low-performing students. In 2000, low-performing students started to show gains. Since 2009, the only group of students to achieve marginal gains were students in the top 10th percentile (Chingos et al., 2019).

Many scholars believed teachers would want to teach in public schools where student achievement improved (Banerjee et al., 2017). Teachers value achievement and welcome school changes which support achievement improvements for students (Dizon-Ross, 2020). For some low-performing schools, there were two possibilities (Saw et al., 2017). Some identified schools were labeled low performing while placing others on a watch list, and some had resources and funding withheld or were forced to close (Saw et al., 2017). The commitment of the USDE to public schools and increasing achievement was indicated by setting goals (Dizon-Ross, 2020). Setting goals for science achievement as well as ELA and mathematics was a step in the right direction to improve education (Achieve, 2017).

The Significance of STEM Education

STEM is an educational approach to integrate the disciplines into 21st century skills (Yildirim & Türk, 2018). Thought to be crucial to encourage innovation, inventions, productivity, and economic growth, STEM was vital (English, 2017). The goal of schools in South Carolina is to produce 21st-century learners (SCDE, 2021).

The National Science Foundation created STEM education to provide all students with an education, including critical thinking and problem-solving skills, especially for underrepresented students (James & Singer, 2017). Some were concerned education could not keep up with the new demands and requirements of the 21st century (Meyer & Norman, 2020). The agreement in literature and research leaned toward integrating an assortment of STEM concepts as a practical and worthwhile effort to introduce to students in grades K–12 (James & Singer, 2017).

The importance was for students across the United States to solve the problems of tomorrow (Morrow, 2020). The U.S. Department of Commerce (as cited in Engineering for Kids, 2016) reported STEM careers were increasing at a rate of 17%, while other careers were only growing at a rate of 9.8%. Students who participated in STEM education in the K–12 setting had an advantage if choosing not to attend college after high school and an even more significant advantage if choosing to attend college, particularly in a STEM-related field (James & Singer, 2017). Students had an increased civic engagement through STEM education, while learning to persevere to receive good grades (James & Singer, 2017).

The responsibility of school districts was to make sure each child had a worthwhile, quality learning environment (Morrow, 2020). STEM education provided a quality learning environment and produced students who knew how to think critically and problem-solve (Engineering for Kids, 2016). Furthermore, STEM education allowed the next generation of students to become innovators (Engineering for Kids, 2016).

The youth are the workers of tomorrow and need a variety of skills (Poth, 2019). Schools need to prepare the youth to develop the skills necessary to solve problems with the knowledge taught and to know how to collect data and evidence to make decisions and evaluate information (Morrow, 2020). Results from international standardized testing and data from employment vacancies showed students in the United States had a deficiency in mathematics and science skills (Israel, 2017, as cited in Ash et al., 2020).

Genuine STEM education provides a vision that gives every student the opportunity to gain STEM-related goals (Holmlund et al., 2018). Innovation and improvements lead to new and improved products and support the economy (Engineering for Kids, 2016). Innovation permeates all aspects of one's life, as people are experiencing new and improved technology all of the time. STEM activities allow students to find different and creative solutions to real-world problems (Ozkan & Topsakal, 2017).

Best Practices in Education

The Profile of a South Carolina Graduate requires graduates to have world-class knowledge (SCDE, 2019b). World-class knowledge includes rigorous language arts and mathematics standards for career and college readiness and knowledge of multiple languages, STEM, arts, and social sciences (SCDE, 2019b). By exposing students to how STEM helps solve real-life problems, students start appreciating the numerous opportunities STEM skills unlock for the students in the future (Holmlund et al., 2018).

Decrease Achievement Gaps

STEM-based schools intended to decrease the achievement gaps in mathematics and science and improve standardized test scores of all K–12 students (Bicer et al., 2015). Schools implementing STEM programs produced better-prepared students for the future and improved the STEM-related workforce by creating innovators (Holmlund et al., 2018). Educators needed to produce 21st-century learners who knew basic science and mathematics (Bicer et al., 2015).

School turnaround is the concept of a quick improvement in student achievement in low-performing schools (VanGronigen & Meyers, 2019). The topic of school turnaround was critical in K–12 public education. Students learn differently; consequently, several different teaching modes were required to reach individual student's needs, which allowed for improved student achievement (Leasa et al., 2020).

Hands-On Learning

Best practices in teaching are centered around the concepts of STEM education (Aquino, 2017). The practices include using meaningful and engaging activities, which allow students to examine the problem in many ways and learn through failure with the engineering design practices and experiences (Estapa & Tank, 2017). Teaching mathematics and science through student-centered activities, which encourages communication and teamwork, is an imperative concept in STEM education (Estapa & Tank, 2017). Crossing boundaries of different school subjects is the basis for integrating STEM education (English, 2016). Teachers needed to make learning active because students learned more and remembered more from doing than listening (Aquino, 2017).

John Dewey was an American philosopher who visualized what was to be known as experiential learning (Cherry, 2020b). Known for his leadership in the progressive movement in education in the United States, Dewey was a proponent of learning by doing (Beard, 2018). The driving force behind John Dewey's educational views was his belief if teachers can relate school to life, then all studies will be correlated and meaningful for students (Masterson, 2016). Learning by and through experiences was a new kind of education in Dewey's time (Pascucci, 2016).

In 1984, David Kolb adopted the idea of learning by doing (Cherry, 2020a). Kolb was an American educational theorist known for his work in experiential learning (Cherry, 2020a). Experiential learning has a four-cycle component: experiencing, reflecting, thinking, and acting

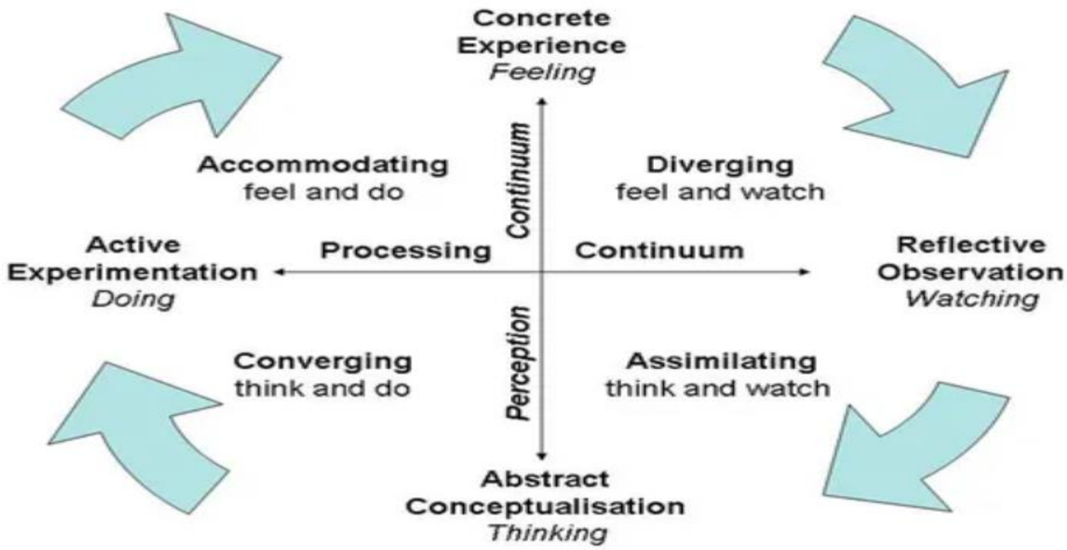
(Kolb & Kolb, 2018). Research showed learning needed to be focused on the student and be engaging (Watson et al., 2019).

According to Kolb, experiential learning was interdisciplinary and facilitated students to create knowledge through experience (Kolb & Kolb, 2018). Learning is a continuous cycle, including concrete knowledge, reflective observations, abstract conceptualization, and active experimentation (McLeod, 2017). Kolb believed knowledge came from the grasping of experiences and transformed understandings (Cherry, 2020a).

There are two main ways of understanding experience, and both are profoundly different: concrete experience and abstract thinking (Kolb & Kolb, 2018). Students ought to understand experiences concretely and then abstractly (Kolb & Kolb, 2017). After the student experiences a concept concretely, the student reflects on and observes the experience (Kolb & Kolb, 2017). As seen in Figure 1, the learner then moves into abstract conceptualization to grasp the learning experience and finally transforms the learning into active experimentation (Kolb & Kolb, 2017).

Figure 1

Processing and Perception Continuum



From *Kolb's Learning Styles and Experiential Learning Cycle*, by S. McLeod, 2017. Copyright 2020 by Simply Psychology. Reprinted with permission (see Appendix A).

The optimization of the brain is for experiential learning and going through the cycle promotes student learning (Kolb & Kolb, 2018). When students realized what they were learning mattered, they became more engaged in the process of learning (Ngo, 2021). Students developed self-satisfaction, knowing the knowledge and skills learned led to important ends (Widya & Rahmi, 2019). Asked through a study by Segalàs et al. (as cited in Watson et al., 2019), educational experts discussed the most beneficial active method for maintaining and retaining learning in students. Eighty-eight percent of the educators in the study supported project-based and hands-on learning as the preferred method of instruction (Watson et al., 2019).

Bloom's Taxonomy

The motivation to learn helped to regulate students' academic success in school (Ngo, 2021). STEM education allowed students to become motivated about learning and allowed the students to have the opportunity to take an active role in learning (Ngo, 2021). Benjamin Bloom was an American psychologist who developed a theoretical framework of mastery learning, which became known as Bloom's Taxonomy, and the revision of Bloom's Taxonomy took place in 2001 (Verenna et al., 2018). The framework measures the complexity of thinking as it considers student learning (Verenna et al., 2018).

To reach the highest level of learning, synthesizing, students originate, integrate, and combine ideas into a product, plan, or proposal of something new (Armstrong, 2018). Synthesizing in the classroom includes students who generate various solutions, formulate solutions, and then implement action plans (Arneson & Offerdahl, 2018). Bloom believed mastery at each level of the taxonomy was the aptitude to complete reasoning achievement at the level of learning (Verenna et al., 2018).

The taxonomy was built on a hierarchical structure and implied, for students to successfully reach one level of Bloom's taxonomy, the student had to at least partially master the primary level (Verenna et al., 2018). To reach the second-highest level of learning, evaluating, the student makes a judgment based on criteria and standards (Armstrong, 2018). In the classroom, students evaluate and incorporate justifying a decision or course of action by checking, hypothesizing, critiquing, experimenting, and judging (Armstrong, 2018).

Bloom's levels of evaluating and creating were the STEM concept of teaching and learning (Baharin et al., 2018). Because students came to the classroom with a wealth of previously learned knowledge, the teacher's responsibility was to use the previous knowledge as a basis for new knowledge (Holmlund et al., 2018). The learning process should be a process of initiative and construction of knowledge (Darling-Hammond et al., 2020). Constructivism supports Bloom's levels of taxonomy (Estapa & Tank, 2017). According to the Constructivist Learning Theory, various resources, encounters, and situations build new knowledge for students (Barak, 2017).

Impact of STEM Education

The school environment and supportive relationships with supervisors and colleagues positively affect a teacher's work within a school (Kiran & Sungur, 2018). The culture around the importance and integration of STEM education allows education to occur through innovative learning (Kelley & Knowles, 2016). Studies showed STEM positively affected the students' learning, attitudes, and perceptions toward STEM (Baran et al., 2019). When teaching STEM, students had a higher attendance rate for mathematics and science classes and higher test scores, all while demonstrating a higher level of engagement in class (Walker et al., 2018).

Students in classrooms where there is an integration of STEM showed positive academic gains (Kelley & Knowles, 2016). Effective STEM education is imperative for students' future success. The education helped students learn how to gain conceptual knowledge of understanding and to transfer the knowledge to other situations (Darling-Hammond et al., 2020).

Perceptions of STEM Education

A priority in education since 2015 has been the push to produce students who were able to become 21st-century learners and educationally prepared for STEM jobs (Preston, 2018). For 21st-century learning to occur, schools equipped students with the ability to participate in a multifaceted world (Benade, 2015). There are many different perceptions when it comes to STEM education.

Student Perceptions of STEM Education

Students are affected daily by STEM education (Darling-Hammond et al., 2020). STEM activities allowed students to find different and creative solutions to real-world problems (Ozkan & Topsakal, 2017). The world was in a new period in which students should have been proficient in STEM areas, even as young as early elementary (Raby, 2015). A student's self-assurance was imperative with any attempt to improve or increase the student's interest and achievement in STEM education (Dubriwny et al., 2016).

In a study conducted with 37 seventh graders in a public school, the students participated in nine different science, technology, engineering, arts, and mathematics (STEAM) activities during a unit of instruction (Ozkan & Topsakal, 2017). Students who participated in the STEAM activities had positive perceptions and saw the learning as enjoyable and exciting, with few negative views about the activities (Ozkan & Topsakal, 2017). Although students found the learning enjoyable, STEM was challenging; therefore, they had a greater sense of accomplishment of the success achieved (Pittinsky & Diamante, 2015).

Goal setting helps a person decides what to do with one's life dreams, which is motivation (SaiRaman, 2019). Motivation allows a person to stop asking questions and looking for excuses and sets the person in the direction toward working for a goal (Cook, 2017). Goals take people step by step in the direction of a dream, and if asked, most people have a dream for achievements in life (SaiRaman, 2019). STEM activities changed a student's attitude toward STEM (Sarı et al., 2018). STEM activities increased attitudes toward STEM and increased students' creativity while improving student motivation (Ugras, 2018).

Out-of-School Programs

Schools across the United States involved different partners in ensuring students had access to high-quality STEM programs, like public libraries, museums, and after-school programs (Afterschool Alliance, 2020). After-school programs became more popular, which allowed over 10 million students in the United States to participate in the programs annually (Brasili et al., 2017). These after-school programs allowed students to participate in STEM programs, which helped the students succeed in school (Afterschool Alliance, 2020). Academic achievement gains during the school day were related to out-of-school programs in STEM (Cutucache et al., 2018). Of the approximately 10 million students who took advantage of after-school programs, approximately 69% were in a program that offered some STEM program (Brasili et al., 2017).

Out-of-school programs were smaller in size than regular classrooms, with a smaller teacher-to-student ratio. Smaller class sizes drastically improved the academic achievement of students (Xie et al., 2015). Depending on the school or school district, out-of-school programs occurred before school, after school, during the summer, or during holiday breaks. The out-of-school programs provided excellent opportunities for students to learn and develop 21^{st}-century skills (Cohen et al., 2019). Schools offering out-of-school STEM programs, especially in the summer, reduced educational inequalities associated with socioeconomic status (Xie et al., 2015).

A study of an out-of-school STEM program by Baran et al. (2019) presented the perceptions of 40 sixth-grade students who participated in the program. The study explored how the students involved valued the hands-on concept in the STEM activities (Baran et al., 2019). The activities provided the students an opportunity to participate in design challenges, which sparked an interest in STEM careers (Baran et al., 2019). There was enthusiasm from the students about STEM concepts by providing opportunities for students to participate in out-of-school programs. Many of the programs provided a more hands-on approach than the students would have received during the school day (Cutucache et al., 2018).

Teacher Perceptions of STEM Education

The school culture influences how teachers perceive different programs, curricula, and ideas (Schleicher, 2018). Teacher efficacy and motivation affected students' academic achievement, especially in science (Taştan et al., 2018). When a school met the needs of teachers, teachers were more effective in the classroom (Reaves & Cozzens, 2018). For a successful STEM education program, teachers' perceptions were focused on the need to promote students' higher-order thinking skills through the culture of the school and academics driven by an integrated curriculum (Darling-Hammond et al., 2020). Many schools focused classroom time on mathematics and reading (Wexler, 2020).

In classrooms all over the United States, teachers were aware the science standards called for a more profound connection to STEM subjects (Ntemngwa & Oliver, 2018). Teachers had to know how to integrate STEM subjects (Ntemngwa & Oliver, 2018). Many in-service teachers found the process of shifting to STEM instruction hard (Margot & Kettler, 2019). In-service teachers often delivered instruction using traditional instructional methods instead of student-focused methods linked to STEM pedagogy (Nowikowski, 2017).

Reports indicated teachers had not obtained college-level preparation at a satisfactory level of complexity to prepare the teachers for courses required to teach (Nowikowski, 2017). Many teachers required technical assistance and support from experts in the field to successfully implement STEM subjects (Ntemngwa & Oliver, 2018). A need existed for an increase in STEM professionals, but research revealed many teachers were unqualified or inadequately taught how to teach and integrate STEM subjects (Firat & Kilinç, 2017).

Training and professional development for teaching STEM subjects were absent (Gardner et al., 2019). Then, teachers generated students with poor STEM experiences and little grounding to enter STEM college majors and careers (Firat & Kilinç, 2017). Teachers who chose to participate in STEM professional development sessions stated the sessions provided the teacher with more confidence and high self-efficacy in teaching STEM concepts (Nowikowski, 2017).

Not all teachers value the importance of STEM education (Gardner et al., 2019). Teachers who were not comfortable and had little knowledge of STEM tended to perceive themselves as unable to teach the STEM activities (Margot & Kettler, 2019). Teachers who were comfortable with and had the education and experience to carry out STEM activities had a high-level efficacy and enjoyed teaching through hands-on learning (Margot & Kettler, 2019).

Barriers to STEM Implementation

While research showed the importance of STEM education in the public school system, the process was not easy for all schools to effectively implement the program (Michels & Eijkelhof, 2019). School districts faced a crucial need to understand the hurdles and challenges which occurred when implementing an integrated STEM curriculum (Shernoff et al., 2017). Schools faced general barriers when implementing STEM education (Michels & Eijkelhof, 2019).

Some of the barriers included a limited number of qualified teachers to implement STEM disciplines, a lack of teacher professional development, and a lack of teacher investment in professional development (Winangun & Kurniawan, 2019). Many colleges had low enrollment in STEM education programs, and of the students enrolled in the program many dropped out and enrolled in non-STEM programs (Glaze, 2018). Approximately one-half of the students who left STEM programs in college enrolled in a business program. Many of the students left the STEM program due to a lack of preparedness in middle and high school (Olson & Labov, 2012).

As STEM education is an integrated program, to achieve the idea successfully, it is crucial to prepare preservice STEM teachers in college for teaching subjects through integrated approaches (Ryu et al., 2019). Motivation is key in implementing and integrating STEM education (Firat & Kilinç, 2017). One factor which affects motivation is effective professional development (Gardner et al., 2019). Staff development on effective STEM education and implementation improved motivation and decreased any programs' misunderstanding while providing the needed support to all involved (Icel, 2018).

A significant cause in students' lack of appreciation for science careers was a deficiency in knowledge of what science involved (Glaze, 2018). With the implementation of STEM education, other foreseeable barriers included students who lacked learning integrated information, students with a deficiency in problem-solving skills, and students with no previous STEM learning and skills (Winangun & Kurniawan, 2019). Other barriers included an unsupportive school system, an absence of collaboration among teachers, and a lack of content knowledge and content delivery skills (Winangun & Kurniawan, 2019). The struggle with mathematical concepts and negative opinions about mathematics highly determined whether a student succeeded or failed (Glaze, 2018).

To effectively implement STEM education, the teachers needed to work together, and the administration needed to give the program full support (Altuger-Genc & Issapour, 2015). Collaboration and support did not necessarily happen in all schools (Ostovar-Nameghi & Sheikhahmadi, 2016). Another obstacle was budget cuts within school districts (Icel, 2018). Due to budget cuts in many school districts across the United States, STEM programs were limited (Icel, 2018).

Contrary Perceptions of STEM Education

Not all researchers found STEM improves students’ academic performance (Kim, 2015).

Even though STEM careers offered above-average wages, the demand for STEM jobs was higher than the number of college students graduating with a STEM degree (Castleman et al., 2017). The impact of STEM programs was different, depending on the student's achievement level with which they started (Han et al., 2015). Implementation of STEM impacted lower-achieving students more than high-achieving students (Han et al., 2015).

Not all believed time, money, and effort should go toward STEM education in schools (Zaloom, 2019). Many people believed too much emphasis was on STEM education, and the emphasis took away from a focus on the humanities (Zakaria, 2015). In 2018, the U.S. education system spent over $26 billion on technology in schools, and globally, around $252 billion (Woodard, 2019). With the emphasis on STEM education, people believed many politicians, including Barack Obama, have steered students away from receiving humanity degrees, such as a degree in art history (Zakaria, 2015).

The job market is constantly changing (Castleman et al., 2017). People believed colleges devoted time and energy to prepare students for jobs in an evasive sense, not specifically STEM jobs, as there were no certainty high-paying STEM jobs would still be open upon graduation (Zaloom, 2019). The dismissal of wide-ranging learning in college put the United States on a dangerous and narrow course for the future (Zakaria, 2015).

The Future of Education

The United States had not been producing enough qualified employees to fill STEM-related jobs (Newman et al., 2015). By integrating STEM activities into out-of-school activities, like an after-school program, enough interest was developed in students to pursue STEM-related careers (Baran et al., 2019). Every person needs to have basic knowledge in math, science, and ELA (Bicer et al., 2015).

In the United States and many nations worldwide, the view of the need for STEM was critical, based on alleged or genuine shortages in the current STEM workforce and the future workforce (English, 2017). Initiatives in STEM education permeated educational reform around the world (Yanez et al., 2019). By providing STEM education, starting as young as preschool age, the education community opened the door for students to become lifelong learners (Office of Innovation and Improvement, 2016).

Engineering education was updated and became the center of devotion in the scientific population in 2015 (Kislyakov et al., 2019). The employment rate for STEM jobs overtook the total job growth in the United States (Graf et al., 2018). Since 2015, employment opportunities in STEM fields increased 79%, going from 9.7 million to 17.3 million jobs (Graf et al., 2018).

Even though STEM jobs paid beyond the national average salary, with most averaging approximately $87,500 annually, studies showed the most significant reason students chose a STEM career was endless creativity (Kislyakov et al., 2019). In 2015, the 8.6 million STEM jobs across the United States represented about 6% of all employment in the country, but compared to other jobs in the United States, STEM jobs doubled (Israel, 2017, as cited in Ash et al., 2020).

Due to a lack of STEM preparedness, many people left the profession (Congressional Research Service, 2018). The trend has since changed for the better. Leading countries, including the United States, created strategies that improved STEM program education, with many of the programs aimed at including women (Kislyakov et al., 2019).

STEM education is comprised of six core principles (Morrow, 2020). Educational activities which promoted planned play and risk, engagement in a group practice, and learning experiences geared around interdisciplinary curriculum allowed for problem solving and engagement (Office of Innovation and Improvement, 2016). Learning spaces, which were flexible and comprehensive, allowed for innovative ways to assess learning (Office of Innovation and Improvement, 2016). Social/cultural environments, which supported diversity and opportunities for all to participate in the learning activities, allowed access to STEM education (Office of Innovation and Improvement, 2016). Across the United States, organizations started to align STEM efforts with the strategic plan of the nation (Morrow, 2020).

By implementing the plan and core principles, schools altered access to STEM education for all students. All students were engaged in the learning environment (Office of Innovation and Improvement, 2016). When done correctly, the improvement in STEM education produced millions of middle- and high-paying jobs across the United States. The jobs added over $1 trillion in annual Gross Domestic Product (Israel, 2017, as cited in Ash et al., 2020).

By pooling resources and involvement among interested parties, opportunities for high-quality STEM experiences reinforce the idea all students, regardless of where the students live, receive the necessary education to be a part of the workforce of tomorrow (Office of Innovation and Improvement, 2016). In 2019, the USDE revealed the department had invested almost $540 million to support STEM education (Morrow, 2020). Studies showed, by 2020, the need for skilled scientists and engineers exceeded the number of qualified applicants by one million (Israel, 2017, as cited in Ash et al., 2020).

Gaps in the Literature

A gap in literature existed as little research had been conducted on STEM education in middle schools, with most of the research conducted in grades 9–12 (Blotnicky et al., 2018). While researching the literature review, many articles focused on STEM education in elementary and high schools. The revamping of the school curriculum to integrate STEM concepts started at the primary grade level and then focused on high school, college, and career placement (Roche

& Manzi, 2019).

The completion of a few studies to investigate teachers' perceptions of the effect of STEM programs on academic success have been done (English, 2016). The basis of many articles was how to teach STEM in schools, but not how educators perceived the effectiveness of STEM initiatives on student academic success, especially across the board by integrating all subject areas. Many teachers felt incompetent to teach STEM (Yildirim & Türk, 2018).

Chapter Summary

STEM education is centered around the Constructivist Learning Theory (Akron & Aşiroğlu, 2018). Transformational leadership supports the innovative ideas around STEM education (Lamm et al., 2016). Studies showed the implementation of STEM education positively affected students' learning (Baran et al., 2019). A gap in literature existed as little research has been conducted on STEM education in middle schools, with most of the research conducted in grades 9–12 (Blotnicky et al., 2018). Few studies investigated teachers' perceptions of STEM programs' impact on academic success (English, 2016). The methodology chapter, Chapter 3, included discussing the research design and rationale, the role of the researcher, and research procedures.

Chapter 3: Methodology

Exploring perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina was the purpose of the case study. The goals of the case study were to identify how educators perceived STEM initiatives. The following research questions guided the study:

Research Question 1: What did middle school educators feel were the benefits students received from participating in STEM programs based on the results of the standardized tests of the state?

Research Question 2: How did educators describe the experiences of students while participating in STEM initiatives?

Research Question 3: How did educators perceive strategies of STEM education to be effective in helping middle school students achieve academic success?

This chapter includes a description of the purpose of the study and an outline of the research questions addressed in the study. The case study answered the how and why questions and explained perceptions to understand better the impact of STEM on student academic success at three middle schools in southeastern South Carolina. Research design and rationale clarified the suitability of qualitative research for the case study. The following section described the role of the researcher. Research procedures described the population and sample size, instrumentation, program, data collection, and data preparation methods to investigate the phenomenon in the problem statement. The fourth section included the analytical factors to address the research questions using the data collected. Reliability and validity explained the procedures used to verify trustworthiness throughout the study and ethical procedures followed to communicate the procedures taken to protect the human participants. The final section was a chapter summary.

Research Design and Rationale

The rationale for using a case study as the research design was the desired purpose to understand the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina (Creswell & Poth, 2018). Case studies explain how and why a social phenomenon works (Yin, 2018). Descriptions in qualitative studies gain insight into the who and what of the experiences as well as the understandings from the participants about a poorly understood phenomenon (Seixas et al., 2017). Qualitative-based research helps to understand the beliefs, experiences, attitudes, activities, and interactions of the participants (van Manen, 2014).

Allowing for a thorough description of events experienced by either an individual or a group of people is the purpose of any case study research (van Manen, 2014). Being explanatory rather than interpretive, qualitative case study research signifies a commitment to studying a phenomenon in its normal state and ensures there is no manipulation of variables or any pretense of a theoretical view of the phenomenon (Seixas et al., 2017). Case studies provide an in-depth understanding through a description of a social phenomenon gained from participants by answering questionnaires and participating in interviews (Yin, 2018).

STEM initiatives are essential to schools, and the knowledge gained was a vital part of a well-rounded education for every student (Office of Innovation and Improvement, 2016). The approach of the case study was to explore perceptions of the effectiveness of STEM initiatives on student success at three middle schools in southeastern South Carolina. Student academic success can be measured both through formative and summative assessments. Formative assessments can be teacher observations, while summative assessments can be unit tests or state assessments (SCDE, 2021).

Case study research has often been used in education and reveals the importance for others in the field to learn from the experiences of educators already in the field (Neubauer et al., 2019). By expanding awareness of the effectiveness of STEM initiatives on student academic in the middle school setting, the study expanded knowledge of the importance and effect of teaching STEM. The research had the potential to expand the perceptions of educators concerning the impact STEM has on the academic success of middle school students (Neubauer et al., 2019).

Qualitative Case Study Research

Qualitative case study was an appropriate research design as educators inexperienced with the implementation of STEM education will be able to learn from the previous experiences of others (Neubauer et al., 2019). There was a need, due to a lack of research, to empower others through the perceptions of educators on the effectiveness of STEM initiatives on student academic success in middle school (Office of Innovation and Improvement, 2016).

Research questions for the study derived from the lack of understanding regarding the perceptions and implementation of STEM initiatives. Case studies have emphasized concepts and ideas in education and explored those concepts with individuals who experienced the phenomenon (Creswell & Poth, 2018). Participants answered the questions and described experiences with STEM education. The case study research occurred in the natural state, and it was ideal for the study (van Manen, 2014). The study drew on the participants' perceptions to allow for an understanding of the meanings the participants attributed to experiences with STEM implementation (Clark & Vealé, 2018).

Role of the Researcher

In qualitative studies, the role of the researcher is to provide a precise and accurate explanation of different experiences, perceptions, and descriptions (Bradshaw et al., 2017). Educators provided detailed descriptions regarding the effectiveness of STEM initiatives. The described perceptions were elicited through an open-ended questionnaire and semistructured interview. Such an opportunity allowed for gainful insight through the lens of educators. All stages of the research plan from interviewing the educators, transcription of the responses, analysis and verification of data, to reporting of the conclusions, were completed methodically (Sanjari et al., 2014).

The interpretation of the meanings from information shared as well as the participants' experiences were made without bias. Responses to the questionnaire and interviews were used, which allowed for verification through two data sources. Perceptions from educators from three middle schools in three school districts in southeastern South Carolina which implemented STEM initiatives were used. There were no personal relationships with anyone from new School A or School C. There was a personal friendship with one teacher from School B. The educator chose not to participate in the study.

There was no power or authority over any of the participants, nor were any favors or incentives offered for participating in the study. The trustworthiness of the data collected during the study was not affected by me being a teacher in School District A, nor by the friendship with one of the teachers at School B, since the person did not participate. Further, study information was not shared with the friend at School B.

Adult human participants over the age of 18 participated in the study, and approval through the ACE Institutional Review Board (IRB) was obtained (Appendices B and C). Participant confidentiality was maintained throughout the study. The identity of the educators remained confidential, as a coding system was used to prevent disclosure of participant identity. Each participant was assigned an alphanumeric character, and any information about participants was identified by this unique character. Study materials and all data obtained were securely stored in a locked safe and will be stored for three years. After three years, the print data will be shredded, and digital data will be erased.

Research Procedures

A qualitative case study of the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina could inspire non-STEM schools across South Carolina and the United States to make STEM initiatives available to their student populations. The findings of the study could illuminate the perceived benefits of implementing STEM initiatives. Each school in the study implemented STEM, allowing schools to see the perceptions of the effectiveness of STEM initiatives as a whole, from multiple viewpoints. The purpose of conducting a case study was to identify human experiences and grasp the nature of the experiences (van Manen, 2014).

Case study research has been popular in education (Creswell & Poth, 2018). A case study was a suitable way to describe perceptions of participants regarding personal experiences with STEM implementation (Clark & Vealé, 2018). As a research methodology, the case study allowed for the exploration of the perceptions of the effectiveness of STEM initiatives on student academic success (Koopman, 2017).

Population and Sample Selection

Educators from three middle schools, grades 6–8, in southeastern South Carolina were participants in the study. The target population consisted of 100 educators from all schools Although the target population was 100 educators, only 15 volunteered to participate in the study. Each participant worked at a school which incorporated STEM initiatives. Each school district was in the 10 largest school districts in South Carolina (SCDE, 2019b). Fifteen educators were provided an online questionnaire through SurveyMonkey (Appendix D) to complete and were then interviewed over the phone (Appendix E). The questionnaire and interview questions explored educator perceptions of the effectiveness of STEM initiatives on student academic success among the participant sample.

School A had approximately 550 students in grades 6–8, with 36 teachers (SCDE, 2019b). Of the 550 students, almost 85% received free or reduced lunch due to low family income (SCDE, 2019b). Due to the high poverty rate of the families, new School A was a Title I school. Since its opening, the mission of the school had been to meet the growing needs within the community and move forward in the quest for academic excellence for every student (SCDE, 2019b). The school was a designated STEM school of science, but the zoning was for the local neighborhood. (SCDE, 2019b). Some STEM initiatives took place in the core content areas, with math, science, ELA, and social studies teachers planning together to incorporate STEM projects. Students were also offered the opportunity to take a pre-engineering class as one of the related arts (elective) classes.

School B had a student population of approximately 1,300 students in grades 6–8, with 43 teachers. Of the 1,300 students, roughly half qualified for free or reduced lunch (SCDE, 2019b). The middle school is a STEAM school, since it not only implemented science, technology, engineering, and mathematics, and art. The integration of STEAM was in all classrooms, and the school offered two different programs to the students: Project Lead the Way and Gateway to Technology (SCDE, 2019b). Although the school was a STEAM school, the questionnaire and interview questions only pertained to the STEM initiatives, and not the art initiatives.

School C had approximately 1,325 students in grades 6–8, with 57 teachers. Of the 1,325 students, just over half qualified for free or reduced lunch, which made the school a Title I school (SCDE, 2019b). The middle school was a STEM school since STEM was integrated into all classrooms (SCDE, 2019b). The school had a STEM advisory board, which implemented a semester-long STEM project in each grade level.

All three schools served grades 6–8. Because collaboration among teachers took place at all schools, teachers at each grade level who taught science, mathematics, social studies, technology, engineering, and ELA were invited to participate in the study (Appendix F). Also asked to participate were administrators and instructional coaches because administrators and instructional coaches not only observe classes but also evaluate school initiatives and student academic success.

The sampling method was purposive and voluntary participants were solicited, which enhanced the trustworthiness of the data gathered (Firat & Kilinç, 2017). At the three schools, administrators were contacted via email to gain approval to use the schools in the study (see Appendices G - I). Purposive sampling allowed for intentionally targeting those who could provide perceptions about the phenomenon under investigation (Creswell & Poth, 2018). Each participant was made aware of the project information and the purpose of the study through the Recruitment Letter (Appendix F) and the Informed Consent Form (Appendix J).

Inclusion and exclusion criteria described who could and could not be part of the study sample (Garg, 2016). Inclusion criteria included factors that made the participants eligible for the study, while exclusion criteria included factors that made part of the recruited target population ineligible (Garg, 2016). Five inclusion criteria required for the study were: participants had at least three years of teaching experience, worked at the present school site for at least two years, had an understanding of the STEM initiatives at the school, had direct knowledge or experience with STEM students, and could explain and discuss student academic success in the classroom. The study excluded any educator not meeting all five inclusion criteria.

Inclusion criteria added reliability to the study (Garg, 2016). Perceptions were from participants who had enough knowledge to make inferences and observations (Creswell & Poth). The participants in the study had direct knowledge or experience with STEM students. Participants were required to have experienced the phenomenon of the STEM initiatives at the school site (van Manen, 2014). The participants worked at the school site for two or more years, allowing the educators to be familiar with the STEM initiatives at the school. The participants were able to describe perceptions of the effectiveness of STEM initiatives on student academic success. Perceptions from the participants provided insight into how educators felt STEM initiatives impacted student academic success.

The added reliability of the study was through the exclusion criteria (Garg, 2016). Participants were required to possess direct knowledge or experience with STEM students. Research has shown the first few years as a teacher can be overwhelming, as the new teacher is trying to learn all of the rules, techniques, and initiatives within the school (Fitchett et al., 2018). To participate in the study, each participant must have had three years of educational experience. Exclusion criteria eliminated educators who had been at the school for less than two years.

Prior to IRB approval, two schools were contacted by email in order to gain approval from the principals to use their schools in the research study (Appendices G - H). After IRB approval was gained (Appendix B), contact was made to both school principals to obtain a contact person at the school, in order to receive a list of prospective participants (Appendices K –

L). After the identification of prospective participants was complete, each person received a recruitment email, asking the person to volunteer to be a participant in the study. Of the 37 qualified to participate, eight volunteered, but then two dropped out of the study after consenting due to an excessive workload at the school. At this point, there were six participants for school B. After sending another recruitment email (Appendix F), no one responded.

Approval was gained from each school principal for participation from Schools A, B, and C. The approvals were received via email correspondence (Appendices G - I). After approval by ACE IRB (Appendix C), the contact person at each school received an email (Appendices K - M). The email requested the names of educators who had at least three years of educational experience, who had been at the school for at least two years, had an understanding of the STEM initiatives at the school, had direct knowledge or experience with STEM students and could explain and discuss student academic success in the classroom. An email letter from the list invited the educators to participate in the study (see Appendix F).

The goal was to use purposive sampling of volunteer participants in order to select educators from different content areas, two related arts areas, and educational roles. The four core subject areas are math, science, ELA, and social studies, along with special education. The two related arts invited to participate were engineering and technology teachers. Due to limited response, the case study consisted of 15 willing participants. All 15 educators who volunteered were a part of the study.

Instrumentation

Prior to any data being collected for research purposes, the participants completed a demographic questionnaire, which consisted of six questions (Appendix N). The demographic questionnaire was administered through SurveyMonkey. Each participant received an email with the link to the demographic questionnaire. The demographic information was needed to ensure each participant met the inclusion criteria. The information from the demographic questions also allowed for the alphanumeric labeling of each participant, based on the name and school of the participant. The role of each participant was used to monitor how many participants were volunteering from different educational roles and content subject areas (Appendix N).

Data from an online questionnaire (Appendix D) and open-ended interviews (Appendix E) were collected. Each questionnaire took approximately 40 minutes to complete, and each interview ranged in time from 30-45 minutes. Questionnaire questions were adapted based on the Teacher Beliefs and Attitudes toward STEM (T-STEM) survey, which the Friday Institute for Educational Innovation created (Unfried et al., 2015). Approval from the Friday Institute for Educational Innovation to use and adapt the survey was obtained (Appendix O). Each subject matter expert received 20 questionnaire questions and 20 interview questions. Based on feedback from the field-testing of the subject-matter experts (Appendix P), 10 questions were chosen for the questionnaire (Appendix D) and 10 interview questions were chosen (Appendix E). The questions for the online questionnaire and open-ended interviews were field tested by five subject-matter experts (Appendix P).

According to research, the T-STEM survey helped administrators decide on different improvements to the school's STEM program (Unfried et al., 2015). The survey identified changes in STEM educators' confidence and effectiveness (Unfried et al., 2015). The survey measured attitudes toward 21st-century learning and the frequency with which participants use instructional practices related to STEM (Unfried et al., 2015).

Questionnaire questions identified changes in the educator's confidence toward STEM and attitudes toward 21st-century learning and instructional practices (Unfried et al., 2015). The questionnaire had seven sections and collected data in all seven sections (Unfried et al., 2015; see Appendix Q). Raw data were deconstructed from the questionnaire and interviews to find keywords and similar ideas and patterns (Belotto, 2018).

Adapted interview questions from a conference paper published by the Museum of Science and Industry in Chicago were used (Chiu et al., 2015). Permission to use and adapt the interview questions was granted (Appendix R). The responses to the questionnaires and interviews were evaluated and codes were created from words and sentences which carried similar meanings (Belotto, 2018).

Data Collection

Data collection took place in the fall of 2020 after approval from the American College of Education IRB (Appendices B and C). Before completing the questionnaire and interview process, all participants were asked to sign an informed consent statement (see Appendix J), which assured participants there would be no identifying information used in the findings from the study. The informed consent form was emailed to all participants. The participants signed the form, either physically or electronically and sent the forms back via email. Data collection took place via an online questionnaire through SurveyMonkey and completed phone interviews. The participants had the option to complete the interview via phone or Zoom. All participants chose to have the interview conducted over the phone. The participants were emailed the SurveyMonkey link in order to complete the online questionnaire.

Before giving the online questionnaire and completing the interviews, participants completed six demographic questions (Appendix N). The demographic data was collected through SurveyMonkey, in which the participants answered the questions. Each participant received an email link to the questionnaire on SurveyMonkey. Data collected from the demographic questionnaire were first and last name, school employed at, educational experience in years, length employed at current school, and educational role at the school. The demographic data was used as a screening tool to determine eligibility of the participants. Demographic data were separated from the questionnaire and interview to maintain the confidentiality of the participants and conceal identities.

Individual interviews obtained information regarding perceptions of the effectiveness of the STEM initiatives on student academic achievement. Each interview took place over the phone, and the responses were recorded using a digital voice recorder. Each participant was made aware the interview was being recorded and each agreed to the recording. Each participant answered 10 open-ended interview questions (Appendix E). The participants answered the same interview questions.

Open-ended interview questions led to a documented and organized description of the experiences and allowed for a deep understanding of the shared experiences among the participants (Neubauer et al., 2019). Each interview lasted between 30 and 45 minutes. Interviews were audio-recorded with a digital voice recorder to allow for verbatim transcription of the responses, and typed notes took place on a laptop during the interview. During the phone interview, the participant was placed on speaker phone so the responses could be recorded by the researcher. Participants were asked permission to be placed on speaker phone and for the responses to be recorded. Each participant agreed to the terms. In order to ensure confidentiality of each participant and protection of privacy during the phone interview, the interviews took place in a home office behind a closed door.

All contact information was checked for accuracy in case any follow-up questions or clarifications were needed. The research data for this study will be securely locked in a safe for three years to ensure participants' confidentiality and will then be shredded. The audio voice recordings will be stored in the same locked safe for three years. After three years, the recordings will be erased.

Data Preparation

A case study approach to qualitative studies strived to describe the principle of the phenomenon through the lens of people who have experienced the phenomenon (Neubauer et al., 2019). The National Science Foundation partially supported the development of the T-STEM survey (Unfried et al., 2015). Questions from the T-STEM survey were modified to collect perception data from the participants regarding teaching confidence, efficacy, and attitudes and frequency data regarding the use of specific STEM instructional practices and technology in the classroom (Appendix Q). The modified questions were validated using five subject-matter experts (Appendix P).

Questionnaire responses were collected through SurveyMonkey (Appendix D). By using SurveyMonkey, the results of the online questionnaire were only available to the researcher, which provided participant privacy. Each participant was given an alphanumeric code for identification purposes. Interview questions (Appendix E) were then analyzed to determine patterns and similarities (Vaughn & Turner, 2015). Results provided a holistic overview of the combined participants' attitudes and the frequency in which activities took place during instructional time (Unfried et al., 2015).

Creswell and Poth's (2018) steps to case study data analysis required managing and organizing the data by creating and organizing data files. Identifications of meanings of the phenomenon were extracted and examined to determine relationships and connections between the data and the phenomenon (Umanailo, 2019). Codes were created based on the relatedness of the responses from the participants.

After the initial codes, themes were created by reviewing responses and looking for trends (Vaughn & Turner, 2015). Creswell and Poth's (2018) final two steps were to develop significant statements and group the statements. By developing textual, structural, and composite descriptions of the STEM initiatives in each of the three schools, representing and visualizing the data then took place.

Data Analysis

Analysis of qualitative data consisted of making sense of the research regarding the participants' definitions of the situation as well as determining patterns, themes, categories, and consistencies (Male, 2016). At the end of the phone interview, member checking occurred. The notes to the responses were read back to the participant for accuracy. During the phone interview, responses to the SurveyMonkey questionnaire responses were read back to the participant, using member checking for accuracy. After reading through the questionnaire and interview responses, themes emerged through both a holistic reading approach and a detailed reading approach (van Manen, 2014).

The holistic reading approach evaluated the responses as a whole and decided on the primary significance of the phenomenon while capturing the writing phenomenon (van Manen, 2014). The selective reading included pulling out statements and phrases from the perceptions of the participants (van Manen, 2014). The detailed reading approach looked at each sentence individually for revelations of the phenomenon (van Manen, 2014). Based on Creswell and Poth's (2018) approach, each participant described the personal experience of the phenomenon.

A constructed list of significant statements concerning how the participants perceived the effectiveness of STEM initiatives on student academic success occurred. Grouping the statements into larger units then took place to create a textual description of the perceptions of the educators. A structural description described how the experiences happened. A composite description was then written, including the textual and structural descriptions (Creswell & Poth, 2018).

In qualitative research, an inductive approach aimed to gather meaning from a phenomenon in a local and natural setting (Young & Hren, 2017). An inductive approach of data analysis grouped the data by themes, looking for any relationships among the data (Neubauer et al., 2019). The approach condensed the textual data into a summary and established links between the research objectives, questions, and summary (Liu, 2016).

By establishing clear links between the evaluation or research objectives, summary findings derived from the raw data developed a basis of the essential arrangement of experiences in the data (Liu, 2016). The approach provided an easily used and methodical set of techniques for analyzing the qualitative data, which produced reliable and valid findings (Bolarinwa, 2015). The use of ATLAS.ti 9 software for coding purposes, along with an open-minded approach, was utilized. The open-minded approach aimed to conceptualize underlying patterns by creating categories (Umanailo, 2019).

Reliability and Validity

Research needed to be reliable and valid (Cypress, 2017). Reliability referred to the degree to which the replication of research could happen (Bolarinwa, 2015). Validity was the level to which a measurement represented the observer's findings and provided an accurate representation of the described phenomenon (Bolarinwa, 2015).

Piloted instruments used in the study occurred with over 500 teachers. The piloted T-STEM instrument had a Cronbach alpha level of .945 (Unfried et al., 2015). Out of the total number of teachers participating in the piloted study, 324 of the participants were middle and high school teachers. The middle and high school subject areas taught by the teachers were science, technology, engineering, and mathematics. The Cronbach alpha levels from each group of questions ranged from .814 to .948 (Appendix S).

The T-STEM survey questions were modified in order in this research to create the questionnaire questions (Appendix D). The modified questionnaire questions were then field tested by five expert subject-matters (Appendix P). The study was a multiple-participant case study with 15 participants from three middle schools. In multiple-participant research, inferences became strengthened once elements repeated with more than one participant (Cypress, 20A17). Through multiple perceptions of the participants, the focus was on the insider perspective of each participant (Cypress, 2017).

The questionnaire questions (Appendix D) were adapted from the T-STEM survey (Appendix O). The original T-STEM questions were validated through the piloted study (Unfried et al., 2015). The adapted questions for the research study were validated using five subject-matter experts (Appendix P). Once permission to use the T-STEM survey was granted, modification of the survey questions occurred (see Appendix O).

For validity and reliability purposes, the Friday Institute for Educational Innovation piloted the science, technology, engineering, mathematics, and elementary T-STEM surveys with 257 science teachers, 72 technology teachers, 17 engineering teachers, 120 math teachers, and 218 elementary teachers (Unfried et al., 2015). A completed formal analysis on science, math, and elementary teachers took place (Unfried et al., 2015).

Cronbach's alpha measured the reliability of a study, which measured internal consistency (Institute for Digital Research & Education, 2016). Internal consistency signified how closely connected a set of items was as a collection or group (Institute for Digital Research & Education, 2016). In general, a Cronbach's alpha level of .90 and above was the best measure of reliability (Institute for Digital Research & Education, 2016). For the T-STEM survey (Appendix S), Cronbach's alpha levels were in the range of .814 to .948 for the middle and high school versions (Unfried et al., 2015).

The interview questions (Appendix E) were adapted from the Science Leadership Institute at the Museum of Science and Industry (MSI) in Chicago, IL. Permission was granted by one of the authors of the research article to adapt the survey questions (Appendix R). The survey questions given by MSI were utilized to create a School Support Tool created in partnership with the Education Policy Center at Michigan State University (Chiu et at., 2015). The MSI questions were validated through the study conducted by MSI. In the study by MSI, 839 K-8 schools were identified to participate in the research and 175 were randomly chosen (Appendix T). For each school, one administrator and one science teacher were asked to respond to the survey questions. Out of the 350 participants asked, 64 responded and completed the survey (Appendix T). The survey was piloted first with a group of administrators and teachers who had been participants in the past in an MSI teacher course (Chiu et al., 2015). After the responses were received, three advisory committee groups validated the responses.

Because the adapted questionnaire and interview questions were from published surveys, the questions needed to be field-tested for validity and reliability purposes. The questionnaire and interview questions were field-tested by five subject matter experts (see Appendix P). Experts identified problems experienced by participants during the study and determined whether the questions asked were in a manner that corresponded to the study (Ismail et al., 2017). Each subject matter expert received the three research questions, which guided the study, 20 possible open-ended questionnaire questions, and 20 possible interview questions.

The subject matter experts chose 10 questions for each category. Questions chosen were the ones that received at least three out of five votes from the subject matter experts. The questions which received two out of five votes went back to the five subject matter experts. The subject matter experts chose the remaining number of questions needed for the study from the selected questions (Ismail et al., 2017).

Triangulation was used with multiple data sources to foster a complete understanding of the phenomenon being studied and tested the validity of the study (Carter et al., 2014). Data triangulation included utilizing different sources of data and information (Fusch et al., 2018). The use of questionnaire questions and interviews constituted data triangulation for the study (Carter et al., 2014).

Environmental triangulation achieved validity and reliability. Environmental triangulation involved using different local settings in which the study took place (Ashour, 2018). In the study, participants from three middle schools in three districts were used, along with teachers from different grade levels who taught different subject areas and administrators and instructional coaches. The achievement of internal validity came about through reflexivity by describing any contextually intersecting relationships between the participants and the observer (Dodgson, 2019). The demographic data did not include race, age, or cultural background in order to reduce bias. The demographic data was a screening tool and only included the name of the participant, school, number of years in education, number of years at the current school, and role at the school. By describing the relationships, the credibility of the study was increased and deepened the understanding of the study (Dodgson, 2019).

Ethical Procedures

Before collecting any data, approval from the ACE IRB occurred (Appendices B - C). Additionally, local permission from the administrator at each school was granted (see Appendices G - I). Informed consent was needed before any data could be collected to ensure ethical research happened (Creswell & Poth, 2018). Informed consent was signed and returned via email, which indicated consent to participate in the study (see Appendix J). The consent form explained participation in the study was voluntary, and the participant could withdraw from the study at any time. The consent form ensured the information of the participants was kept confidential. Through the informed consent form, participants were made aware the study may be published.

Each participant was a consenting adult over 18 who was an employee at one of three middle schools in southeastern South Carolina. Disclosure of the purpose of the study was in the recruitment letter (Appendix F) and informed consent form (Appendix J). Contrary findings, alongside the consensus of multiple perceptions, were reported as noted by Creswell and Poth (2018). Data from the study were kept confidential and secure in a locked file cabinet. By shredding after three years, the destruction of the data will take place. The recordings on the audio recorder will be erased after three years.

Chapter Summary

The purpose of the case study was to explore the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina. In the study, 15 participants answered a questionnaire and participated in an interview. Validity and reliability were achieved by field-testing the questions with five subject-matter experts (Appendix P). Common themes and ideas from the perceptions were clustered for coding purposes to understand the phenomenon.

In the methodology chapter, the research design and rationale, the role of the researcher, research procedures, data collection, data analysis, reliability and validity, and ethical procedures for a qualitative case study took place. The study has the potential to expand the perceptions of educators on the impact STEM could have on the academic success of middle school students.

In the following chapter a discussion of the research findings, data analysis, and results is included. Chapter 4 will include the credibility and transferability of the study as well as an examination and analysis of the data of the study.

Chapter 4: Research Findings and Data Analysis Results

The background of the qualitative case study was focused on the importance of the future workforce in South Carolina. If South Carolina were to be relevant in the workforce, quality STEM education in schools was imperative (Bicer et al., 2015). The extent of the problem focused on how vital teaching STEM was in grades K–12. The problem was not all middle school students, grades 6–8, performed at a level of readiness across southeastern South Carolina. The following research questions guided the study:

Research Question 1: What did middle school educators feel were the benefits students received from participating in STEM programs, based on the results of the standardized tests for the state?

Research Question 2: How did educators describe the experiences of students while participating in STEM initiatives?

Research Question 3: How did educators perceive strategies of STEM education to be effective in helping middle school students achieve academic success?

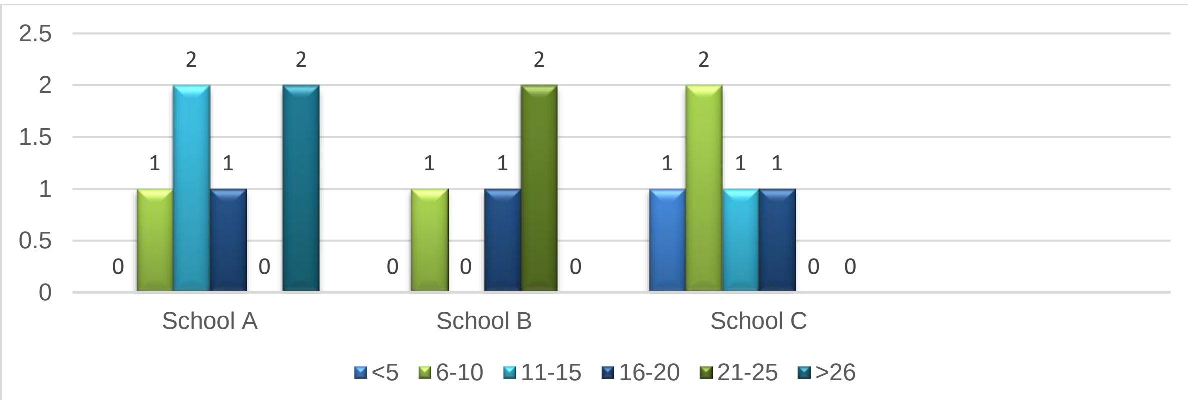
According to South Carolina standardized tests, students who attended a school with STEM initiatives were more likely to score at the level of readiness for the next school year (SCDE, 2019b). The purpose of the qualitative case study was to explore the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina. Chapter 4 included a discussion of the research findings and data analysis for the qualitative case study. The arrangement of chapter 4 was in sections describing the data collection, data analysis, results, and reliability and validity.

Data Collection

Data collection consisted of utilizing an open-ended questionnaire and semistructured interviews of 15 participants in three middle schools in southeastern South Carolina. The participants were a mixture of educators in the three schools. Each participant had at least three years' educational experience and at least two years' experience at the current school (Figure 2).

Figure 2

Participants' Years of Educational Experience



After an evaluation and comparison of themes for each participant, the data revealed an alignment of themes. There was saturation in the data was reached so (Creswell & Poth, 2018, pg. 96). Out of the 15 participants in the study, 14 had the same type of perceptions of the effectiveness of STEM initiatives on student academic success. Triangulation occurred as multiple methods of collecting data were used and participants were from multiple schools and districts (Creswell & Poth, 2018). After participants completed the online questionnaire, which consisted of 10 open-ended questions, a semistructured interview was conducted to gather more information and clear up any questions based on responses.

Before any data collection from participants occurred, each participant received a consent form (Appendix J) via their school email who met the criteria to participate in the study. The contact person at each school provided the names of educators who met the criteria, as described in Chapter 3 (Appendices K - M). A recruitment letter was emailed to the prospective participants (see Appendix F). The email described the purpose of the study, the data collection protocols, and the informed consent letter (see Appendix J). The recruitment email requested each participant return the signed informed consent letter, indicating a willingness to participate Appendices F and J).

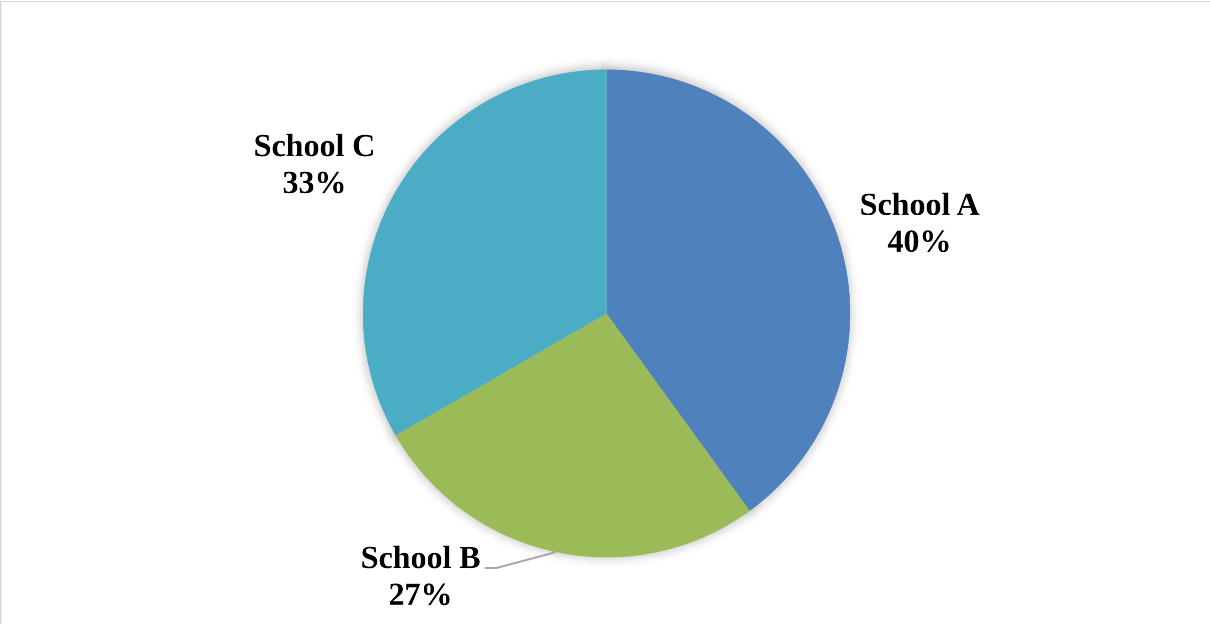
Data collection began on September 25, 2020 and ended on November 3, 2020. The first received signed informed consent form came on September 25th, and the final signed consent form needed to meet the minimum number of participants was received on October 21, 2020. The final informed consent response rate was 13% (15 out of 114), as two participants ceased participation during the data collection stage, after they consented to participate.

Demographics

Prior to any data being collected for research purposes, the participants completed a demographic questionnaire, which consisted of six questions (Appendix N). The demographic questionnaire was administered through SurveyMonkey. The results of the demographic questionnaire revealed out of the 15 participants, seven had 15 years or more educational experience (see Figure 2). The average years of educational experience at new School A was 17.25 years, 18 years at School B, and eight and a half years at School C. Overall, the participants had an average of five years of experience at the current school (Figure 3). The demographic questionnaire also revealed new School A had six participants, School B had four participants, and School C had five participants (see Figure 3). The percentage of participants from each school was similar. The percentage allowed for a more even distribution of perceptions from each school.

Figure 3

School Participation in the Research Study



The data collected for the study captured the perceptions from three types of educators in middle schools that implemented STEM programs. Fifteen educators from three middle schools in three districts in southeastern South Carolina took part in the study. It is a common practice for teachers of all subject areas to collaborate during their planning sessions, therefore the participants had a mix of educational roles (see Table 1). One of the ELA teachers taught Reading 180, a program for students who were two or more grade levels below in reading. One special education teacher, one instructional coach, and two administrators were also part of the study.

Table 1

Participant Job Title/Role

Job title/role	*n*
Social studies teacher	4
English Language Arts teacher	3
Math teacher	2
Science teacher	2
Administration	2
Special education teacher	1
Instructional coach	1
Total	15

Collection of Data

The data for the study were collected virtually. All of the open-ended questionnaires were completed through SurveyMonkey. The questionnaires took an average of 40 minutes to complete. Participants had a choice to complete the semistructured interview either over the phone or through Zoom. All participants chose to complete the interviews over the phone and participants provided phone numbers to complete the interviews.

Each participant was interviewed separately with the duration of each interview ranging from 30 to 45 minutes. The interviews were conducted after participants completed the online open-ended questionnaire through SurveyMonkey. The interviews were recorded using an EVIDA 2324 digital voice recorder. In addition to recording the interviews, the responses were transcribed. Each interview comprised 10 questions. After each interview, the recording was saved and transcribed using Express Scribe Transcription software, which transcribed the interviews verbatim. Member checking was done at the end of the interview, as the responses from notes taken during the interview were read back to each participant.

Data Deviations

Two deviations from the data collection plan presented to the IRB occurred (Appendices B and C). The first deviation was the number of schools participating in the study. The original data collection plan was only intended for two middle schools to be in the study. Because the needed number of participants could not happen using only two schools, there was an addition of a third middle school (Appendix C). The second deviation occurred because of the extra responsibilities and new teaching methods implemented by teachers due to COVID-19. The lack of participants volunteering to be a part of the study reduced the number of participants from 20 to 15 (Appendix C).

Significant and Unusual Events

There were several significant and unusual events and circumstances encountered during data collection. The unusual event plaguing the world during data collection was the COVID-19 pandemic. The pandemic closed schools in March 2020, and the reopening of schools in the fall of 2020 produced challenges for schools across the United States. Some districts started school completely virtual, while other districts provided in-person as well as virtual education options. Some teachers taught strictly in-person or virtual, while others taught dual-modality. Some districts changed teaching modalities based on COVID-19 cases in the school or district. Students also went back and forth between in-person schooling and virtual schooling, based upon the request of the parent or guardian. The changes in the education setting made it difficult to acquire volunteers for the study.

Before IRB approval, two schools (original School A and School B) were contacted via email to gain approval from the principals to use their schools in the research study (Appendix H). After IRB approval, contact to both schools occurred again to obtain a contact person at the school to provide a list of prospective participants. The original School A research site administrator rescinded permission to participate in the study due to all of the changes taking place in education due to COVID-19. Contact of another middle school principal occurred via phone to replace the original School A. Approval was given over the phone for new School A and then through email (see Appendix G). The proposal was re-sent to the IRB, with approval granted (see Appendix C).

Based on the list of 33 prospective participants provided by the new School A site, three volunteered to participate. As more participants were still needed, another recruitment email (Appendix F) was sent out, asking for additional volunteers. One person volunteered, bringing the new School A participants total to four. School B responded with the name of a contact person (see Appendix L). After the identification of prospective research participants took place, each person received a recruitment email requesting volunteers for the study. Of the 37 qualified to participate, eight volunteered, but then two dropped out due to an excessive workload, leaving only six participants. After sending another recruitment email, no one responded.

When it was determined no more participants would come from the two schools, the decision was made to include a third school and drop the number of participants for the study from 20 to 15. Eleven schools were contacted, and one school responded affirmatively, hence IRB approval was needed again (see Appendix B). A third submission to the IRB was submitted, and IRB granted permission, adding the third school, School C, and reducing the number of participants in the study from 20 to 15 (see Appendix C).

The contact person for School C provided a list of educators who fit the inclusion criteria (Appendix M). An email was sent from the researcher's school email address asking for volunteer participants (Appendix F). Of the 44 qualified prospective participants, five volunteered to participate, bringing the total number of participants in the study to 15.

Data Analysis

Throughout the data analysis process, the questionnaire and interview responses identified emerging themes of the participants' experiences and perceptions. The use of ATLAS.ti 9 allowed for the coding of the data from both the questionnaire and interview. By analyzing the collected data and exploring the responses, a deeper understanding of the participants' perceptions and themes emerged.

Coding and Identification of Themes

Since the administration of the questionnaire was through SurveyMonkey, the participants' responses were exported into a Microsoft Word document. Each document pertained to a single question and contained all of the participants' responses. The uploading of the document into ATLAS.ti 9 occurred, where coding took place. Each of the 10 questionnaire responses was evaluated. All responses for each question were read over multiple times, looking for key terms and phrases. A total of 117 codes emerged from the questionnaire responses.

Coding occurred on both the questionnaire responses and the interview answers bringing the combined number of codes to 179. Based on the responses to both data tools, six themes emerged: academic achievement, fostering critical thinking, long-term impact for students, implementation strategies, challenges in implementation, and the needs of teachers to implement initiatives. The 179 codes were placed into one or more of the six groups, or themes. Common codes were combined, and the final number of codes was 148.

The data were transcribed from the interview responses. As the participants completed the semistructured interview via telephone, each interview was audio-recorded. After each interview, a transcription of the audio recording was generated using Express Scribe Transcription software. The participants' perceptions of the phenomenon of STEM initiatives required an in-depth study of the interview responses. Utilizing the notes and transcribed interviews helped to provide an unbiased, valid, and credible understanding of the different perceptions of the educators involved in the study.

The exact process used for the questionnaire responses and the data analysis of the interview responses was identical. The analysis began with coding keywords and phrases and then grouping the codes into common themes. When participants described the same type of perception, a theme emerged. The coding process started with 117 codes from the questionnaire responses, then 62 new codes were added based on the interview responses. Similar codes were combined at the end, for a total of 148 codes, while six themes emerged. The six themes were: academic achievement, fostering critical thinking, long-term impact for students, implementation strategies, challenges in implementation, and the need of teachers to implement STEM initiatives.

The goal was to identify the essential ideas of the participants, which helped support an understanding of the educators. Through the analysis of the qualitative data, each participant's response had equal weight. Even if the response was opposite to the viewpoints of the other participants, the exact weight was the same.

Results

Six themes emerged from the data collected from the educators from the three middle schools across three school districts in southeastern South Carolina. The use of the ATLAS.ti 9 software categorized the emerging themes. Data mining was used, along with the coded data, to cluster all data. The emerging themes were academic achievement, how STEM fosters critical thinking skills, long-term impact on students, implementation strategies, challenges in implementation, and the needs of teachers to implement STEM initiatives. The themes which emerged answered the three research questions (see Table 2).

Table 2

Research Questions and Themes

Research question	Themes
RQ1: What did middle school educators feel were the benefits students received from participating in STEM programs, based on the results of the standardized tests for the state?	Theme 1: Academic achievement Theme 2: Critical thinking
RQ2: How did middle school educators describe the experiences of students while participating in STEM initiatives?	Theme 2: Critical thinking Theme 3: Long-term impact
RQ3: How did middle school educators perceive strategies of STEM education to be effective in helping middle school students achieve academic success?	Theme 4: Implementation Theme 5: Challenges Theme 6: Teacher needs

Response to Research Question 1

Research Question 1 asked, what did middle school educators feel were the benefits students received from participating in STEM programs, based on the results of the standardized tests for the state?

Theme 1: Academic Achievement. Questionnaire Question 3 asked the participants, How does STEM help both high- and low-achieving students? Participant A3 responded,

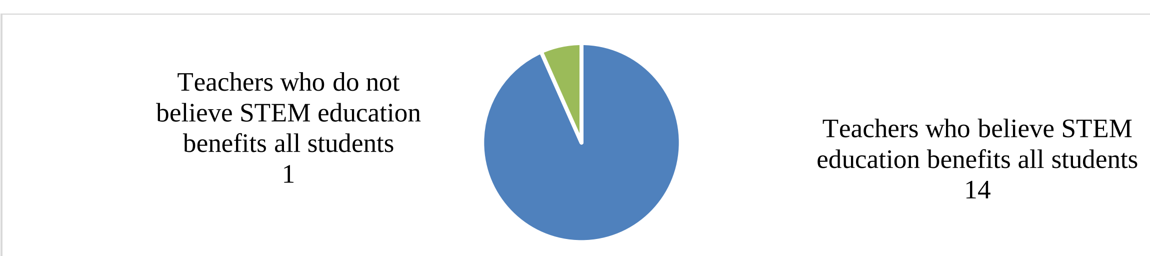
> STEM has helped our students because many of them come from low-income families and don’t realize they have a way out. STEM allows them to focus on what they can do with their mind and hands. STEM allows students the opportunity to find ways of successfully working together. Most of the students I taught are deficient in this skill. Through teamwork, students at all levels are provided the opportunity to be successful.

Participant C1 had a different outlook, stating, “Opportunities for group collaboration over interesting material and projects is never a bad thing for either learning group but in reality, low achieving students benefit most from explicit direct instruction.”

Participant B2 responded to Question 7 on the questionnaire (How are students able to reason both abstractly and quantitatively through STEM?) with, “We first figure out what we change, then how to change it and finally how that impacts the world.” However, not all teachers felt the same way. Participant C1 did not think low-achieving readers should participate in STEM initiatives, stating, “STEM cuts into Reading 180 time. Is it really what they should be doing if they cannot read?” Only one participant of the 15 had the perception STEM did not benefit all students, especially low-achieving readers (see Figure 4).

Figure 4

Participants Who Believe STEM Benefits All Students



Participant perceptions of student academic achievement improved in many aspects, not only in math and science (see Table 3). Participant C3 taught the same students in eighth grade as taught in sixth grade. Looping means teachers teach the same students in different grade levels. Two years later, the looping gave Participant C3 a perspective on the changes over the two years

Participant C3 responded to the interview question, What are differences noticed pertaining to student perseverance in terms of STEM education? as follows:

> Students who are in eighth grade now are able to use better and different strategies than the same students did in sixth grade. The students have a much greater strength in problem solving and know how to take apart questions, in order to find the answers.

Improvement in academic achievement occurred across the curriculum. Social studies teachers perceived students gained a deeper understanding of history and knew how history compared to society today. Social studies teachers observed students relating geography to science, as with the study of migration, wetlands, and pollution. According to teacher observations, students become more proficient writers because of the cross-curricular concept of STEM (see Table 3). Educators perceived the improved academic achievement in students and the higher quality of lesson planning by teachers, which correlated to improved instruction in the classroom.

Table 3

Academic Achievement

Code	No. times used in participants' responses
Problem solving/learning from mistakes	21
Critical thinking skills	13
Benefits all students/all involved in learning	9
Extends learning/growth of students	8
Answering/asking questions and discussion	8
Improved instruction by teacher	7
Deeper understanding	7
Justify work/reasoning	5
No repetition and/or reciting of facts when learning	4
Better writers/higher vocabulary skills	4
Make connections to learning	3
Perseverance/confidence in learning	3
Does not benefit low-achieving students	3
Students do not always like deeper thinking/no achievement difference	2
Ownership/passion in learning	2

Theme 2: Fosters Critical Thinking. The educators discussed how STEM fostered critical thinking skills (see Table 4). Teachers gave students real-world situational problems the teachers believed had no easy answer or solution. The teachers and instructional coaches

perceived the situations challenged the students' abilities and allowed for problem-solving. According to the participants interviewed, the ability to think critically allowed the students to find solutions to the problems at hand. In the questionnaire, Participant C2 responded,

> Students develop problem-solving skills by practicing things like project-based learning, and by having an education which frames problems in a way which need to be solved by using skills obtained in multiple disciplines. This is a much more realistic approach for students, since in life do we rarely have problems which can be solved by just one discipline.

Table 4

Fosters Critical Thinking Skills

Code	No. times used in participants' responses
Problem solving	19
Critical thinking skills	13
Real-world problems/applications	12
Challenging/increased rigor	6
Analyze data/evaluate	6
Abstract thinking	4
Questioning	3
Using a variety of solutions	3
Deeper understanding	3
Ask questions	3
Reasoning/recognize patters	2
Learn from mistakes	2
Justify thought process and answers	1

Participant C3 answered questionnaire Question 4 pertaining to how students develop problem-solving skills:

> By collaborating with each other. They brainstorm ideas together, work with different opinions and ideas, they learn how to verbalize with each other productively, they practice/manipulate the problem at hand while making mistakes but figuring out by

themselves how stuff works on their own.

Response to Research Question 2

Research Question 2 asked, How did educators describe the experiences of students while participating in STEM initiatives? Results throughout the data analysis occurred, and significant insights arose from the data. The central epiphany which emerged as a theme in data analysis was the idea of the long-term impact of STEM on students (see Table 5). The number of different codes emerging within the theme of the long-term impact of STEM education was not expected.

Table 5

Long-Term Impact on Students

Code	No. times used in participants' responses
Problem solving	29
Application to the real world	29
Critical thinking skills	24
College and career ready	8
Self-motivated	7
Improve future life/way out of poverty	7
Develop self-growth	7
Learn more/ownership of learning	6
Job skills/greater work ethic	6
Deeper understanding/skill set	6
Creativity	6
Become an active member of society/global citizens	6
Make connections to learning	4
Learn from mistakes	4
Interest in the future	4
Computer applications	4
Answering questions	4
Abstract thinking	4
Student leadership skills/conflict management	3
Productive struggle	3
Justify thoughts/reasoning	3
Exposure to careers and science opportunities	3
Better writers/higher vocabulary	3
Analyze data	2

Theme 2: Fosters Critical Thinking. Theme 2, described under Research Question 1, was additionally tied into Research Question 2. Critical thinking skills impacted students' academic achievement and were part of the experiences the students obtained through the STEM initiatives. Participants perceived the experiences obtained by students not only fostered the use of critical thinking skills during the activity but also taught the students new critical thinking strategies from peers during the activity.

Theme 3: Long-Term Impact on Students. A second insight within the theme of long-term impact for students was how STEM could bring a student out of poverty. Perceptions became apparent in the coding, indicating STEM allowed students to become active members of society while allowing a plentitude of opportunities not customarily be provided to the students (see Table 5). In terms of long-term impact on students, Participant A2 commented,

> Students can see different careers, what people do and how they use STEM. Students need to know problem-solving aspects for all jobs. The problem-solving skills help build on for the future and the students need to know different techniques.

Theme 2, described under Research Question 1, additionally tied into Research Question 2. Critical thinking skills impacted students' academic achievement and were part of the experiences the students obtained through the STEM initiatives.

Response to Research Question 3

Research Question 3 asked, How did educators perceive strategies of STEM education to be effective in helping middle school students achieve academic success? Participants from three middle schools in three counties in southeastern South Carolina were a part of the study. Although each middle school implemented STEM initiatives differently, all three schools had several codes in common.

Theme 4: Implementation Strategies. Regardless of if the school had a school-wide STEM initiative or a lab or pre-engineering class available for some students, the main implementation strategies focused on real-world applications, culminating projects, hands-on learning, and problem-solving (see Table 6). Of the 169 total usages of codes for implementation strategies, 90, or 53%, came from the four areas (see Table 6).

Table 6

Implementation Strategies

Code	No. times used in participants' responses
Project-based learning	29
Applications to the real world	29
Culminating project	18
Hands-on learning	14
Engineering design cycle/scientific methods	9
Applied learning	7
Communication with local governments	6
Technology in the classroom	5
Teacher as a facilitator	5
Field trips	5
Exposure to career and science opportunities	5
Share learning experiences with others/public speaking	4
Gifted classes/high school credits in middle school	4
Computer applications	4
Asking questions	4
3-D printing/coding video games	4
STEM lab	3
Questioning	3
STEM every day in class	2
Analyze data	2
Student leadership	1
Arts integrated	1

Participant A4 stated, "Consistent focus needs to be on application, with less rote knowledge. Application facilitates the process of more skills being learned, which are based on the interest of the students." As the case study was completed in middle schools in southeastern South Carolina, many participants perceived real-world field trips as a significant implementation strategy, living close to beach areas. Participant B1 described a yearly kayaking trip all students take, based around STEM:

> [The kayak trip] allows for students to solve real-world problems outside of the classroom. During the yearly kayak trip, students not only test the runoff water for water quality and pesticides, but look for pollution based off fish signs, read and write about water quality, using the book "River of Words" and complete an art project after the trip.

Participant A4 noted the school district offers a summer STEM camp, stating, "It is awesome, I even send my own kids to the camp."

Theme 5: Challenges to Implementation. The data showed most educators who participated in the study agreed STEM initiatives benefitted all students. The participants realized initiatives needed to be implemented across the curriculum, but many spoke of the challenges in implementing STEM. To fully implement a program, all staff members needed to be on board, and in some instances, not all teachers were willing to participate (see Table 7).

Table 7

Challenges to Implementation

Code	No. times used in participants' responses
All teachers need to participate	14
Time consuming for teachers	10
Consistency	5
Teachers do not know how to fully implement STEM	4
No college prep for teaching STEM	4
Lack of funding	4
Lack of communication amongst staff	4
Not enough resources and materials	3
Teachers need a better understanding of STEM	3
Too many standards to teach	3
Leadership needs to promote STEM	3
Turnover rate of teachers	2
Teachers are not creative enough	2
Large class sizes	1
Higher caliber of volunteers needed	1
Cuts into special reading class for low-achieving readers	1
Buy-in needed from parents and students	1

A lack of funding and resources hindered implementation. Some grants were sought and awarded, but not always. Teachers felt burdened by the amount of time involved in implementing STEM initiatives fully. Participant C3 mentioned during the interview, “Time management is a huge challenge for teachers; there is never enough time to do all of what is wanted or required to do.”

Sixteen percent of the responses regarding the challenges in implementation theme cited science, technology, engineering, and math being too time-consuming (see Table 7). The high teacher turnover negatively impacted implementation, as Participant A4 responded, “Parents and teachers do not always stay involved. At times, it is hard to maintain personnel who are willing to be in charge.”

Theme 6: Teacher Needs to Implement STEM. Throughout the questionnaires and interviews was an overwhelming desire for the students to obtain the best education possible. However, 15 different responses by the participants revealed the teachers did not feel qualified to implement STEM initiatives (see Table 8). The participants noted teachers did not feel confident due to a lack of understanding of how to implement STEM initiatives. Teachers perceived college did not adequately prepare them in the area of STEM implementation. Seventy-five percent of the teachers believed if more assistance, including professional development, were offered, implementation would be easier and more effective (see Table 8).

Table 8

Teacher Needs

Code	No. times used in participants' responses
Time consuming for teachers	10
Teachers do not know how to fully implement STEM	8
Professional development	7
Cross-curricular planning	7
Funding provided	5
Consistency	5
Communication among teachers	5
Add STEM one step at a time	4
Help generating ideas	3
Grade-level meetings to discuss STEM	3
Few projects a year	2
Emphasis moved away from computer-based testing	2
STEM should not be a priority	1
Greater STEM leadership	1

Reliability and Validity

In qualitative research, reliability and validity were criteria for judging the quality of the research design (Yin, 2018). To establish reliability and validity, the instrumentation, saturation of data, and trustworthiness of the research needed to be addressed (Yin, 2018). The validation process assessed the accuracy of the findings which were best described through the participants' perceptions (Creswell & Poth, 2018).

The first test of reliability and validity occurred through the instrumentation using questionnaires and interviews from participants in three middle schools. Environmental triangulation was used in the study to construct validity. Through the use of three local settings where the study took place, the implementation of environmental triangulation provided validity. Participants were from three middle schools in three school districts across southeastern South Carolina. Participants included educators from different grade levels who taught different subject areas.

Even though environmental triangulation took place, saturation in the data still occurred. Saturation was the second test of reliability and validity in the study. Internal validity occurred when one of the 15 participants did not have the same perceptions and viewpoints about STEM initiatives as the other 14, which helped validate the study. The different perception of the one participant was recorded and documented in the data provided in the study. As each participant was interviewed, the same perceptions came up time and time again and no new information was being gathered (Creswell & Poth, 2018). Participants who had less than three years' educational experience and less than two years of experience at the schools where the study took place were not allowed to volunteer.

The third test of reliability and validity, trustworthiness occurred in the study. There was an open mindset when collecting and analyzing the data. Voluntary participants were from three schools in three school districts across Southeastern South Carolina. The participants were a group of educators who would have the best perceptions of the effectiveness of STEM initiatives on student academic success.

Consistent strategies were throughout the study. When data collection began, each prospective participant received an email invite to volunteer for the study. After a response email was received, the participant was sent the informed consent form to read and sign via email. Once the participant returned the informed consent form, the participant then received the demographic survey via SurveyMonkey. The information on the demographic survey included the participant's name, school, subject taught, years of educational experience, and years of experience at the school (Tables 1 and 2). Once the years of experience were verified, the participant received the online questionnaire through SurveyMonkey. Each questionnaire was identical and consisted of 10 open-ended questions. After completing the questionnaire, participants completed the interview over the phone. Each participant answered 10 interview questions, and all participants had identical questions.

Qualitative case studies could not transfer to another population (Yin, 2018). The findings from the case study were the participants' perceptions within three middle schools in southeastern South Carolina, which might not be the same at other middle schools across the United States. The findings from the case study were on the perceptions of the effectiveness of STEM initiatives on student academic success.

Chapter Summary

The chapter outlined the data analysis and the results of the qualitative case study and the instrumentation, reliability, and validity. The study used two primary data-generating instruments: an online questionnaire and an interview. The study consisted of 15 educators from three middle schools. Data collection procedures and analysis process aligned with the research questions, which guided the study. Participants' responses from the online questionnaire and the interview were coded and resulted in six emergent themes.

Theme 1 was the participants' perceptions of how STEM impacted student academic achievement. Ninety-three percent of the participants in the study believed STEM initiatives improved students' academic achievement on formative and summative assessments and state standardized tests. One participant in the study did not believe STEM improved the academic achievement of students.

Theme 2 emerged as the participants discussed perceptions related to whether STEM fostered critical thinking skills. Ninety-three percent of the educators believed by providing students with real-world problems which have a variety of solutions, students use problem-solving and critical thinking. Through the fostering of critical thinking, students were challenged more and, in return, gained a deeper understanding of the academic material.

Theme 3 related to the long-term impacts of STEM. The participants described many experiences students obtained from the school initiatives, all tied to critical thinking and problem solving through real-world applications. The experiences not only impacted the students while in school but had long-term impacts for the students. One-third of the participants believed, by exposing middle school students to STEM, the long-term impacts allowed the students to obtain a better future and provided a way out of poverty.

Theme 4 centered on the implementation strategies of STEM in the three middle schools. The three middle schools used different strategies. While each school implemented STEM initiatives differently, the implementations were geared around real-world experiences for students, taught problem solving, and fostered critical thinking skills.

The participants believed there were many challenges in fully implementing STEM, which emerged as Theme 5. Lack of funding and resources were problems at most of the schools. Six participants expressed the importance of having a school leader who promoted

STEM. All of the participants agreed a significant amount of time was needed to implement STEM. Due to turnover rates among administration and staff, a lack of consistency was a challenge in implementing STEM.

Theme 6 revealed participants' perceptions around the needs of teachers to implement STEM adequately. One-fifth of the participants stated college did not prepare the teachers to implement STEM effectively, and more professional development was needed. Five participants perceived a lack of creativity and stated teachers needed help generating ideas to implement STEM fully. Forty percent of the participants believed teachers needed more professional development for better implementation strategies.

An examination of discussions and conclusions takes place in Chapter 5. The chapter outlines the findings and conclusions of the study, limitations, recommendations, and implications for leadership. The chapter concludes with a summary of the study.

Chapter 5: Discussion and Conclusion

The purpose of the qualitative case study was to explore the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina. The qualitative case study provided several key findings. Fifteen educators from three middle schools in southeastern South Carolina took part in the case study. The participants had experience within a school which had a STEM initiative. Fourteen of the 15 participants believed STEM benefitted all students, especially in teaching students to use critical thinking and problem-solving skills to complete real-world, hands-on projects.

Research Question 1 focused on the perceptions of the participants concerning academic achievement on the standardized tests for the state. As seen in Figure 4, 93% of the participants in the study believed STEM benefitted all students. Of the 41 codes and 111 uses, two of the codes, problem-solving and critical thinking, were used a combined 32 times. Overall, the participants deemed STEM initiatives to improve students' academic achievement on formative and summative assessments and state standardized tests, as seen in Table 3. Critical thinking skills was a theme that emerged from the responses. Table 4 represented how the participants perceived STEM fosters critical thinking. Of the 18 codes in Table 4, three principal codes emerged: critical thinking, problem-solving, and real-world applications. The three codes combined were used 54% of the time in responses tied to critical thinking and academic achievement.

Determining the many experiences students attained while participating in STEM was the purpose of Research Question 2. Students attained various experiences from the school initiatives, all tied to critical thinking and problem solving through real-world applications. The codes from Table 4, fostering critical thinking skills, pertained to Research Questions 1 and 2.

The experiences described by the participants had a short-term impact on the students and had long-term impacts for all (see Table 5).

Research Question 3 focused on the implementation of STEM at the three schools. Each of the three middle schools implemented different STEM initiatives (see Table 6). Even so, the implementations were centered around real-world experiences for students, teaching problem solving, and fostering critical thinking skills. Participants believed by exposing students to real-world problems and situations, critical thinking and problem solving occurred through projects and hands-on learning. All of the STEM initiatives were student-centered. Two subthemes emerged in responses to Research Question 3: challenges of implementation (see Table 7) and teachers' needs to better implement STEM (see Table 8).

Major sections to follow included discussions of the findings, interpretations, and conclusions of the study. Limitations and recommendations were made, and implications for leadership were discussed, followed by a chapter summary.

Findings, Interpretations, Conclusions

The analysis resulting from the three research questions revealed perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina. The themes which emerged out of educator perceptions were how academic achievement was improved, fostering critical thinking, long-term impacts on students, challenges in implementation, and the needs of teachers for better implementation. The themes were studied and compared to the literature reviewed in Chapter 2. Furthermore, the findings from the contextual framework were analyzed and interpreted.

Findings in Comparison to Literature Review

Constructivist learning theory, zone of proximal development, and transformational leadership were the basis for the findings from the data. Three research questions organized the study. Through the data analysis, six themes emerged: academic achievement, fostering critical thinking, long-term impact for students, implementation strategies, implementation challenges, and teachers' needs to implement STEM initiatives. The six themes, based on the three research questions, were compared to the research reviewed in Chapter 2.

Research Question 1

Students' academic achievement due to STEM initiatives was part of the literature reviewed in Chapter 2. Research Question 1 asked what did middle school educators feel were the benefits students received from participating in STEM programs, based on the results of the standardized tests for the state? Students' capabilities connected to shifts in academic achievement, which were affected due to changes throughout the world (Tan et al., 2017). The shift allowed students to move from only obtaining knowledge from the teacher to needing mastery of multiple skills (Barak, 2017). The Constructivist Learning Theory was built on the concept students learn by doing instead of just being told (Barak, 2017). Participants in the case study believed the implementation of STEM extended students' learning and growth through the hands-on learning process. Nugroho and Wulandari (2017) believed students took an active role in the learning process through experiences was the basis of constructivism in the classroom.

Bicer et al. (2015) believed schools implemented STEM to decrease the achievement gaps and improve standardized test scores. Data from the study showed educators believed implementing STEM produced better writers and improved students' vocabulary skills. More students were involved in answering and asking questions in the classroom, according to the participants.

The majority of participants perceived STEM benefitted all students by improving instruction by the teacher in the form of teachers having students utilize problem-solving skills and learning from mistakes through hands-on learning. A study by Watson et al. (2019) showed 85% of the teachers in the study supported hands-on learning as the favored instruction method. Students who participated in STEM in the classroom displayed positive gains academically (Kelley & Knowles, 2016). The case study data portrayed participants' perceptions of students gained a deeper understanding of the content material through hands-on learning, as implemented by STEM initiatives.

Participant C1 disagreed with the other participants concerning the belief all students benefitted from STEM. Not all studies revealed STEM improved the academic performance of students (Kim, 2015). While 14 of the 15 participants believed STEM benefits all students, Participant C1 thought only students enrolled in the gifted classes benefitted and stated STEM should not be a priority in schools. Zaloom (2019) believed STEM should not take all the time, money, and effort in schools. Others believed the allocation of too much money and emphasis went to STEM (Zakaria, 2015). Participant C1 thought improving student literacy should be emphasized more.

Research Question 2

Students' experiences tied to STEM initiatives were another aspect of the literature reviewed in Chapter 2. Research Question 2 focused on how educators described the experiences of students while participating in STEM initiatives. Studies showed STEM to be crucial for students to encourage innovation (English, 2017). The case study data showed different STEM experiences allowed students to think critically about real-world problems. Engineering for Kids (2016) found STEM produced students who knew how to problem-solve and think critically because of the different experiences in class.

Data from the case study supported the idea STEM provided students real-world experiences and prepared the students to become active members of society. There was a concern in society in which education was not keeping up with the ever-changing demands of the 21st century (Meyer & Norman, 2020). Data collected from Theme 3 produced 24 codes. The participants used the 24 codes 179 times. The three codes used the most were applications to the real world, critical thinking, and problem-solving, and were used 46% of the time (see Table 5). Ozkan and Topsakal (2017) found activities around STEM enabled students to find numerous and creative solutions to real-world problems.

Data collected depicted participants in the study discussed the perception STEM experiences provided students with a deeper understanding of the content and developed multiple skill sets, including self-growth. Dubriwny et al. (2016) found self-assurance of students was essential in succeeding in improving or increasing the interest and the achievement in STEM education. Different types of STEM programs granted students multiple opportunities to learn and develop 21st-century skills (Cohen et al., 2019).

Research Question 3

Sections of the literature reviewed in Chapter 2 discussed strategies used to implement STEM initiatives. Research Question 3 focused on how educators perceived strategies of STEM education to be effective in helping middle school students achieve academic success. Studies showed integration of STEM was a best practice for education (Margot & Kettler, 2019).

The study collected data from participants in three middle schools located in three districts across southeastern South Carolina. Although each school implemented STEM differently, the participants had similar viewpoints on best practices and strategies. Because the implementation process was different for the three schools, participants listed different instructional challenges and benefits in implementing STEM. The themes which arose from discussing effective STEM initiatives were different implementation strategies, implementation challenges, and teachers' perceptions to implement the initiative adequately. Data collected for Research Question 3 exhibited features of the theoretical framework regarding transformational leadership and constructivism.

The study data revealed participants believed the implementation strategies allowed students to learn problem-solving skills through inquiry-based hands-on learning (see Table 6). TES Editorial (2018) found having a student-centered learning environment while implementing inquiry-based learning and projects was the foundation of constructivism. Using real-world culminating projects with hands-on learning was the main strategy participants in the study used and perceived to be the most beneficial to students. Piaget believed in the active construction of knowledge through engagement in hands-on learning and exploration (Csizmadia et al., 2019). Vygotsky believed project-based learning was a best practice in education, which led to the scaffolding of new information for the students (Clark, 2018).

Implementation strategies data (see Table 6) showed participants in the study thought using the engineering design process; students learned from mistakes and applied learning to other areas of education to solve problems. Morrow (2020) found the importance for students to become prepared in school to solve future problems. In school, the learning process should be geared around students constructing knowledge while learning through STEM initiatives (Darling-Hammond et al., 2020).

The data produced 17 challenges with STEM implementation strategies (see Table 7). Perceptions in the data revealed not all teachers felt comfortable or qualified to implement STEM in the classroom. Participants discussed the importance of a supportive leader in the school who was passionate and consistent about implementing STEM. Beliefs were shared, which revealed if the principal was not on board with STEM initiatives, the teachers felt the initiative was not essential and did implement the initiatives with fidelity. Research showed transformational leadership positively changed a school (Lamm et al., 2016).

Anderson (2017) found school leadership was a critical factor for solid teacher and student performance. Data from the present study (see Table 7) showed participants believed STEM could be implemented at a greater level if all teachers participated. The participants realized not all principals support STEM, hence when there was a change in leadership, there was a change in attitude among the staff. Research showed transformational leaders highlighted the best in staff because leadership focused on innovations, reform, and change (Lamm et al., 2016). A high level of staff motivation had ties to transformational leadership (Kouni et al., 2018).

A third theme emerged regarding Research Question 3 relating to what the participants believed was needed for teachers to thoroughly implement STEM (see Table 8). Teacher efficacy affected the academic achievement of students (Taştan et al., 2018). Three teachers in the study felt as though college had not prepared the teachers for knowing how to implement STEM in the classroom. Nowikowski (2017) found in-service teachers delivered most of the instruction in classrooms using traditional teaching methods instead of integrating STEM.

The data from the teachers in the study revealed a need for more professional development. Gardner et al. (2019) found many schools lack training and professional development for teaching STEM. Research showed teachers who chose to participate in professional development to learn STEM implementation felt more confident and had a higher self-efficacy level to implement numerous classroom strategies (Nowikowski, 2017).

Limitations

The application of five limitations was a part of the study. The employed years the participants had at the school was the first limitation. The limitation excluded some teachers at the schools from participating in the study as some teachers did not have at least two years of experience at the school site. Participants also had to have an understanding of the STEM initiatives at the school, have direct knowledge or experience with STEM students, and could explain and discuss student academic success in the classroom.

Credibility was established in the study. The two main techniques used to obtain credibility were triangulation and member checking. Data triangulation occurred when multiple instruments were used to collect data. Environmental triangulation took place because three schools in three different school districts were used in the study. Member checking occurred when the notes of the interview were read back to the participant, giving them the opportunity to make any changes and additions.

An establishment of trustworthiness and consistency among the 15 participants was through the documentation of data collected. Each of the 15 participants completed the online questionnaire through SurveyMonkey, and each phone interview was audio-recorded and transcribed. Participants were made aware the interview was being recorded at the beginning of the phone interview, and each agreed. The data was documented through the six themes which tied to the research questions (see Table 2). Support for the findings of each research question was by data collected and quotes from participants.

The last limitation of the study was the methodology was chosen: a case study. The study could not be transferred entirely to every setting using the chosen method. The study described the participants' viewpoints and perceptions at the three schools involved in the study. The case study did provide some transferability as participants were from three schools. Participants from all three schools experienced teaching different subject areas, different educational roles, and different years of experience. Since the participants were only from three schools and the study was based on the perceptions of the educators at the schools, the findings of the study are not generalizable to all populations. While two of the schools were Title I schools due to the percentage of students who received free and reduced lunch; School B was not a Title I school. All three schools implemented the STEM initiatives differently.

Recommendations

Recommendations for future research were provided as follows, along with changes in school practices grounded in the themes which emerged from the study's data analysis. Additional research should explore the lack of STEM programs in middle schools, elementary schools, and high schools. Different research methods should include quantitative and mixed-method research approaches. Additional research should analyze state standardized test scores in schools with STEM programs to answer how students perform better at all grade levels who participate in the program for greater accountability (Dizon-Ross, 2020).

Additional research should be focused on district offices in school districts across the United States to determine why STEM programs are not in all schools. Each school district was unique in some aspect and the reasons might differ. School district policies should focus on implementing research-based best practices in education. Through a hands-on inquiry-based approach, constructivist learning had improved academic achievement since being traced back to Jean Piaget (Smith, 2017). School board members and district office staff should find funding to allocate to all schools to implement STEM. Policymakers should ensure all schools have adequate funding for STEM programs as not all schools offered opportunities appropriate to the students' needs (Bottia et al., 2018). STEM education to students in low-socioeconomic schools and living in impoverished communities improved students' future lives and has the potential to help remove students from a life of poverty (Darling-Hammond et al., 2020).

Research could be conducted at colleges with teaching programs to determine if preservice teachers are being taught strategies regarding how to implement STEM to see if the findings corroborate the perceptions in this study. The majority of the participants did not feel competent to implement STEM, even though three had graduated within the past six years. Prior research indicated teachers were not receiving adequate college-level preparation to prepare teachers to implement STEM (Nowikowski, 2017). The college research should include interviews with the department chairpersons and the college professors and students in teacher preparation programs. Educational practices in K–12 schools are shifting to prepare students to become 21st-century citizens.

Implications for Leadership

The results of the study may have significance to the field of education and school leaders in the United States. The results revealed perceptions of the effectiveness of STEM initiatives on student academic success at three middles schools in Southeastern South Carolina. The research findings of educator perceptions of the effectiveness of STEM initiatives on student academic success will be provided to state and district educational leaders as well as school principals. The study aimed to provide a holistic overview of the perceptions of the effectiveness of STEM. Future implementation of the recommendations of the study may benefit not only educators in schools across the United States but students and teacher preparation programs at colleges as well.

State and District Educational Leaders

The perceptions of educators revealed STEM provided students with critical thinking skills to solve real-world problems. The Profile of the South Carolina Graduate consists of goals for high school students to have world-class knowledge, world-class skills, and life and career characteristics students upon high school graduation (SCDE, 2019b). World-class knowledge included proficiency in STEM. World-class skills included creativity, critical thinking, problem-solving, and other skills teachers perceived students learn through STEM initiatives and programs. Some of the life and career characteristics revealed in the data from this study included self-direction, which implied perseverance.

School Principals

Future studies could benefit school principals across the United States with improved strategies to be used in the classroom to create 21st-century learners. The study provided educator perceptions of student experiences through STEM initiatives. The study allowed principals to see the theoretical premise of constructivism in classrooms as a best practice teaching method.

The study showed participants believed the more supportive a school principal was in implementing STEM, the more effective teachers were in the implementation process. Not all teachers felt competent in implementing STEM and needed support, which could come from more professional development.

College Leaders

The perceptions in the study revealed teachers wanted to implement STEM in the classroom but were unsure how to achieve the implementation. Teachers relied on what was learned in college for implementation in classrooms. One-fifth of the participants who graduated college within the past six years of the time of this study did not feel prepared to fully know how to implement STEM initiatives. STEM preparation coursework could be added to postsecondary curricula.

Conclusion

The qualitative case study explored perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in southeastern South Carolina by understanding the perceptions of the educators involved in the study and gaining in-depth knowledge into the insights of the perceptions of the effectiveness of STEM initiatives occurred. The 15 participants were from three middle schools in three counties in southeastern South Carolina.

Analyzed data from the questionnaires and interviews of the educators, and the results of the qualitative case study revealed six major themes. The six themes related to STEM perceptions were: academic achievement, fostering critical thinking, long-term impact for students, implementation strategies, challenges in implementation, and the need of teachers to implement initiatives. The second theme, fostering critical thinking through STEM, overlapped both Research Question 1 and Research Question 2.

Several limitations applied to the case study, with the number of participants being 15 from just three schools. Even with the limitations, the case study explored perceptions from a diverse group of participants in schools that implemented STEM in different ways. While complete transferability was not possible as the study was a case study, the diverse group of participants allowed some transferability to other schools and school districts.

The study contributed to the growing interest and need for further research on implementing STEM in middle schools. Perceptions in the study revealed STEM initiatives significantly and positively impacted middle school students. The state and district level and principals at the local school level were given educational recommendations. Furthermore, teacher programs at the college level received recommendations.

Based on the data, educators perceive teaching critical thinking skills in the classroom by implementing the solving of real-world problems through hands-on projects improved the academic achievement of middle school students and provided students an opportunity for a better future. Not all teachers felt competent to implement STEM in the classroom. Others expressed a need for professional development in STEM and better training in postsecondary teacher education programs. Overall, 14 of the 15 participants believed STEM programs benefitted all students in the classroom, regardless of the students' academic ability.

References

Achieve. (2017). *Leveraging ESSA to promote science and STEM education in states*. https://www.achieve.org/files/Achieve_STEMreport7.12.17.pdf

Achieve. (2020). *College and career readiness*. https://www.achieve.org/college-and-career-readiness

Afterschool Alliance. (2020). *Afterschool & STEM learning*. http://www.afterschoolalliance.org/stem.cfm

Akron, S. K., & Aşiroğlu, S. (2018). Perceptions of teachers towards the STEM education and the constructivist education approach: Is the constructivist education approach preparatory to the STEM education? *Universal Journal of Educational Research*, *6*(10), 2175-2186. https://doi.10.13189/ujer.2018.061016

Altuger-Genc, G., & Issapour, M. (2015). Preparing STEM teachers for integration of NGSS: A summer workshop development. *Journal of Education and Learning*, *9*(4), 305–313. https://doi.org/10.11591/edulearn.v9i4.2369

Anagün, Ş. S. (2018). Teachers' perceptions about the relationship between 21st century skills and managing constructivist learning environments. *International Journal of Instruction*, *11*(4), 825–840. https://doi.org/10.12973/iji.2018.11452a

Anczyk, A., Grzymała-Moszczyńska, H., Krzysztof-Świderska, A., & Prusak, J. (2019). The replication crisis and qualitative research in the psychology of religion. *International Journal for the Psychology of Religion*, *29*(4), 278–291. https://doi.org/10.1080/10508619.2019.1687197

Anderson, M. (2017). Transformational leadership in education: A review of existing literature. *International Social Science Review*, *93*(1), 1–15.

http://digitalcommons.northgeorgia.edu/issr/vol93/iss1/4

Aquino, L. (2017, September 6). *10 best practices of highly effective teachers*. Global Educator Institute. http://geiendorsed.com/blog/inspiration/10-best-practices-of-highly-effective-teachers/

Armstrong, P. (2018). *Bloom's taxonomy*. https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

Arneson, J. B., & Offerdahl, E. G. (2018). Visual literacy in bloom: Using Bloom's taxonomy to support visual learning skills. *CBE—Life Sciences Education*, *17*(1), 1–8. https://doi.org/10.1187/cbe.17-08-0178

Ash, A. A., II, Wiggan, G. A., & Watson-Vandiver, M. J. (2020). *Teacher education to enhance diversity in STEM: Applying a critical postmodern science pedagogy*. Routledge.

Ashour, M. L. (2018). Triangulation as a powerful methodological research technique in technology-based services. *Business & Management Studies: An International Journal*, *6*(1), 193–208. https://doi.org/10.15295/v6i1.209

Baharin, N., Kamarudin, N., & Manaf, U. K. (2018). Integrating STEM approach in enhancing higher order thinking skills. *The International Journal of Academic Research in Business and Social Sciences*, *8*, 810-822. https://doi.10.6007/IJARBSS/V8-I7/4421

Banerjee, N., Stearns, E., Moller, S., & Mickelson, R. A. (2017). Teacher job satisfaction and student achievement: The roles of teacher professional community and teacher collaboration in schools. *American Journal of Education*, *123*(2), 203–241. https://doi.org/10.1086/689932

Barak, M. (2017). Science teacher education in the twenty-first century: A pedagogical framework for technology-integrated social constructivism. *Research in Science*

Education, *47*, 283–303. https://doi.org/10.1007/s11165-015-9501-y

Baran, E., Bilici, S. C., Mesutoglu, C., & Ocak, C. (2019). The impact of an out-of-school STEM education program on students' attitudes toward STEM and STEM careers. *School Science and Mathematics*, *119*(4), 223-235. https://doi.10.1111/ssm.12330

Beard, C. (2018). Dewey in the world of experiential education. *New Directions for Adult and Continuing Education*, *2018*(158), 27–37. https://doi.org/10.1002/ace.20276

Belotto, M. J. (2018). Data analysis methods for qualitative research: Managing the challenges of coding, interrater reliability, and thematic analysis. *The Qualitative Report*, *23*(11), 2622–2633.

Benade, L. (2015). Teachers' critical reflective practice in the context of twenty-first century learning. *Open Review of Educational Research*, *2*(1), 42–54. https://doi.org/10.1080/23265507.2014.998159

Bess, C. (2019). *Unpacking STEM disciplines*. National Science Teaching Association. https://www.nsta.org/science-and-children/science-and-children-february-2019/unpacking-stem-disciplines

Bicer, A., Navruz, B., Capraro, R., Capraro, M., Oner, A., & Boedeker, P. (2015). STEM schools vs. non-STEM schools: Comparing students' mathematics growth rate on high-stakes test performance. *International Journal on New Trends in Education and their Implications*, *6*(1), 138–150.

Blagg, K., Chingos, M., Luetmer, G., & Rosenboom, V. (2020). *America's gradebook: How does your state stack up?* Urban Institute. http://apps.urban.org/features/naep/

Blotnicky, K. A., Franz-Odendaal, T., French, F., & Joy, P. (2018). A study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career activities on the likelihood of pursuing a STEM career among middle school students. *International Journal of STEM Education*, *5*(22), 1–15. https://doi.org/10.1186/s40594-018-0118-3

Bolarinwa, O. (2015). Principles and methods of validity and reliability testing of questionnaires used in social and health science researches. *Nigerian Postgraduate Medical Journal*, *22*(4), 195–201. https://doi.org/10.4103/1117-1936.173959

Bottia, M. C., Stearns, E., Mickelson, R. A., & Moller, S. (2018). Boosting the numbers of STEM majors? The role of high schools with a STEM program. *Science Education*, *102*(1), 85–107. https://doi.org/10.1002/sce.21318

Bradshaw, C., Atkinson, S., & Doody, O. (2017). Employing a qualitative description approach in health care research. *Global Qualitative Nursing Research*, *4*, 1–8. https://doi.org/10.1177/2333393617742282

Brasili, A., Allen, S., & Foster, M. (2017). *Afterschool coaching for reflective educators in STEM*. https://mmsa.org/wp-content/uploads/2018/07/ACR_Evaluation-Report-1_201706.pdf

Brown, L. L. G. (2019). *Francis Keppel—1964*. Kappa Delta Pi. https://www.kdp.org/aboutkdp/laureates/keppelfrancis.php

Buck Institute for Education. (2020). *What is PBL?* PBL Works. https://www.pblworks.org/what-is-pbl?gclid=EAIaIQobChMIsYGm5Y3x6gIVjbbICh3EPQgcEAAYASAAEgLWkPD_BwE

Carolina School Hub. (2020). *Best middle schools in South Carolina*. https://www.carolinaschoolhub.com/best-middle-schools-sc.cfm

Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., & Neville, A. J. (2014). The use of triangulation in qualitative research. *Oncology Nursing Forum*, *41*(5), 545–547. https://doi.org/10.1188/14.onf.545-547

Castleman, B. L., Long, B. T., & Mabel, Z. (2017). Can financial aid help to address the growing need for STEM education? The effects of need-based grants on the completion of science, technology, engineering, and math courses and degrees. *Journal of Policy Analysis & Management*, *37*(1), 136–166. https://doi.org/10.1002/pam.22039

Cherry, K. (2020a). *Biography of psychologist David Kolb*. Very Well Mind. https://www.verywellmind.com/david-kolb-biography-2795505

Cherry, K. (2020b). *John Dewey biography*. Very Well Mind. https://www.verywellmind.com/john-dewey-biography-1859-1952-2795515

Chingos, M. M., Kress, S., Ladner, M., Loeb, S., Peterson, P. E., Petrilli, M. J., & Polikoff, M. (2019). *What to make of the 2019 results from the "Nation's report card."* Education Next. https://www.educationnext.org/make-2019-results-nations-report-card/

Chiu, A., Price, A., & Ovrahim, E. (2015). *Chicago-area K–8 teacher and administrator perceptions of STEM education*. Museum of Science and Industry Chicago. https://www.msichicago.org/fileadmin/assets/educators/science_leadership_initiative/SLI_survey_final.pdf

Clark, K. A., & Vealé, B. L. (2018). Strategies to enhance data collection and analysis in qualitative research. *Radiologic Technology*, *89*(5), 482-485. https://pubmed.ncbi.nlm.nih.gov/29793921/

Clark, K. R. (2018). Learning theories: Constructivism. *Radiologic Technology*, *90*(2), 180–183. https://www.asrt.org/main/news-publications/publications

Cohen, M. D., Therriault, S., Scala, J., Lavinson, R., & Brand, B. (2019). *Afterschool programming as a lever to enhance and provide career readiness opportunities*. College and Career Readiness and Success Center at American Institutes for Research. https://ccrscenter.org/sites/default/files/Afterschool%20Career%20Readiness.pdf

Congressional Research Service. (2018). *Science, technology, engineering, and mathematics education: An overview*. www.crs.gov

Cook, N. (2017, February 24). *Why motivation is important in life*. https://www.nataliecook.com/blog/why-motivation-is-important-in-life

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Sage Publications.

Csizmadia, A., Standl, B., & Waite, J. (2019). Integrating the constructionist learning theory with computational thinking classroom activities. *Informatics in Education*, *18*(1), 41–67. https://doi.org/10.15388/infedu.2019.03

Cutucache, C., Boham, T., Luhr, J., Sommers, A., Stevenson, N., Sointu, E., Mäkitalo-Siegl, K., Kärkkäinen, S., Valtonen, T., Grandgenett, N., & Tapprich, W. (2018). NE STEM 4U afterschool intervention leads to gains in STEM content knowledge for middle school youth. *Cogent Education*, *5*(1), Article 1558915. https://doi.org/10.1080/2331186X.2018.1558915

Cypress, B. S. (2017). Rigor or reliability and validity in qualitative research: Perspectives, strategies, reconceptualization, and recommendations. *Dimensions of Critical Care Nursing*, *36*(4), 253–263. https://doi.org/10.1097/DCC.0000000000000253

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied*

Developmental Science, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

DeMink-Carthew, J., & Olofson, M. W. (2020). Hands-joined learning as a framework for personalizing project-based learning in a middle grades' classroom: An exploratory study. *Research in Middle Level Education Online*, *43*(2), 1–18. https://doi.org/10.1080/19404476.2019.1709776

Desilver, D. (2017). *U.S. students' academic achievement still lags that of their peers in many other countries.* https://www.pewresearch.org/fact-tank/2017/02/15/u-s-students-internationally-math-science/

Dizon-Ross, R. (2020). How does school accountability affect teachers? Evidence from New York City. *Journal of Human Resources*, *55*(1), 76–118. https://doi.org/10.3368/jhr.55.1.1015.7438r1

Dodgson, J. E. (2019). Reflexivity in qualitative research. *Journal of Human Lactation*, *35*(2), 220–222. https://doi.org/10.1177/0890334419830990

Dubriwny, N., Pritchett, N., Hardesty, M., & Hellman, C. M. (2016). Effect of Fab Lab Tulsa on student self-efficacy toward STEM education. *Journal of STEM Education*, *7*(2), 21–25.

Dunfey, T. S. (2019). *What is social change and why should we care?* Southern New Hampshire University. https://www.snhu.edu/about-us/newsroom/2017/11/what-is-social-change#:~:text=Sociologists%20define%20social%20change%20as,long%2Dterm%20consequences%20for%20society

El Nagdi, M., Leammukda, F., & Roehrig, G. (2018). Developing identities of STEM teachers at emerging STEM schools. *International Journal of STEM Education*, *5*(1), 1–13. https://doi.org/10.1186/s40594-018-0136-1

Engineering for Kids. (2016). *Why is STEM education so important?*

https://www.engineeringforkids.com/about/news/2016/february/why-is-stem-education-so-important-/

English, L. D. (2016). STEM education K–12: Perspectives on integration. *International Journal of STEM Education*, *3*(1), 1–8. https://doi.org/10.1186/s40594-016-0036-1

English, L. D. (2017). Advancing elementary and middle school STEM education. *International Journal of Science and Math Education*, *15*, 5–24. https://doi.org/10.1007/s10763-017-9802-x

Estapa, A. T., & Tank, K. M. (2017). Supporting integrated STEM in the elementary classroom: A professional development approach centered on an engineering design challenge. *International Journal of STEM Education*, *4*(6), 1–16. https://doi.org/10.1186/s40594-017-0058-3

Fendos, J. (2018). US experiences with STEM education reform and implications for Asia. *International Journal of Comparative Education and Development*, *20*(1), 51–66. https://doi.org/10.1108/IJCED-10-2017-0026

Firat, M., & Kilinç, H. (2017). Opinions of expert academicians on online data collection and voluntary participation in social sciences research. *Educational Sciences: Theory & Practice*, *17*(5), 1461–1486. https://doi.org/10.12738/estp.2017.5.0261

Fitchett, P. G., McCarthy, C. J., Lambert, R. G., & Boyle, L. (2018). An examination of US first-year teachers risk for occupational stress: Associations with professional preparation and occupational health. *Teachers and Teaching, 24*(2), 99-118. https://doi.org/10.1080/13540602.2017.1386648

Fusch, P., Fusch, G. E., & Ness, L. R. (2018). Denzin's paradigm shift: Revisiting triangulation in qualitative research. *Journal of Social Change*, *10*(1), 19–32.

https://doi.org/10.5590/JOSC.2018.10.1.02

Gardner, K., Glassmeyer, D., & Worthy, R. (2019). Effects of STEM professional development on teachers' knowledge, self-efficacy, and practice. *Frontiers in Education*, *4*, 1–26. https://doi.org/10.3389/feduc.2019.00026

Garg, R. (2016). Methodology for research. *Indian Journal of Anesthesia*, *60*(9), 640–645. https://doi.org/10.4103/0019-5049.190619

Glaze, A. L. (2018). Teaching and learning science in the 21st century: Challenging critical assumptions in post-secondary science. *Science Education*, *8*(1), 1–2. https://doi.org/10.3390/educsci8010012

Graf, N., Fry, R., & Funk, C. (2018). *7 facts about the STEM workforce*. Pew Research Center. https://www.pewresearch.org/fact-tank/2018/01/09/7-facts-about-the-stem-workforce/

Han, S., Capraro, R., & Capraro, M. M. (2015). How science, technology, engineering, and mathematics project-based learning (PBL) affects high, middle and low achievers differently. *International Journal of Science and Mathematics Education*, *13*(5), 1089–1113. https://doi.org/10.1007/s10763-014-9526-0

Henning, J. E., Rice, L. J., Dani, D. E., Weade, G., & McKeny, T. (2017). Teachers' perceptions of their most significant change: Source, impact, and process. *Teacher Development*, 1-18. https://doi.org/10.1080/13664530.2016.1243570

Holmlund, T. D., Lesseig, K., & Slavit, D. (2018). Making sense of "STEM education" in K–12 contexts. *International Journal of STEM Education*, *5*(32), 1–18. https://doi.org/10.1186/s40594-018-0127-2

Horrigan-Kelly, M., Millar, M., & Dowling, M. (2016). Understanding the key tenets of Heidegger's philosophy for interpretive phenomenological research. *International*

Journal of Qualitative Methods, *15*(1), 1–8. https://doi.org/10.1177/1609406916680634

Huet, I. (2018). Research-based education as a model to change the teaching and learning environment in STEM disciplines. *European Journal of Engineering Education*, *43*(5), 725-740. https://doi.org/10.1080/03043797.2017.1415299

Icel, M. (2018). Implementation of STEM policy: A case study of a STEM-focused urban charter school. *Journal of STEM Education*, *9*(3), 1–7.

Institute for Digital Research & Education. (2016). *What does Cronbach's alpha level mean?* https://stats.idre.ucla.edu/spss/faq/what-does-cronbachs-alpha-mean/

Iqbal, A., Aziz, F., Farooqui, T. K., & Ali, S. (2016). Relationship between teachers' job satisfaction and students' academic performance. *Eurasian Journal of Educational Research*, *16*(65), 1–35. https://doi.org/10.14689/ejer.2016.65.19

Ismail, N., Kinchin, G., & Edwards, J. (2017). Pilot study, does it really matter? Learning lessons from conducting a pilot study for a qualitative PhD thesis. *International Journal of Social Science Research*, *6*(1), 1–17. https://doi.org/10.5296/ijssr.v6i1.11720

Jamaluddin, N. S., Kadir, S. A., Alias, S. N., & Abdullah, A. (2019). Scaffolding through project-based learning on the change of student achievement: A study in accounting principles subject. *International Journal of Academic Research in Business & Social Sciences*, *9*(9), 567–577. https://doi.org/10.6007/IJARBSS/v9-i9/6330

James, S. M.., & Singer, S. R. (2017). From the NSF: The National Science Foundation's investments in broadening participation in science, technology, engineering, and mathematics education through research and capacity building. *CBE: Life Sciences Education*, *15*(3), 1–8. https://doi.org/10.1187/cbe.16-01-0059Johnson, C. C., Walton, J. B., & Peters-Burton, E. (2018). *STEM road map for middle school*. NSTA Press.

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, *3*(11), 1–11. https://doi.org/10.1186/s40594-016-0046-z

Kier, M. W., & Blanchard, M. R. (2020). Eliciting students' voices through STEM career explorations. *International Journal of Science and Math Education*, *19*, 151-169. https://doi.10.1007/s10763-019-10042-z

Kim, H. (2015). Inquiry-based science and technology enrichment program for middle school-aged female students. *Journal of Science Education & Technology*, *25*, 174–186. https://doi.org/10.1007/s10956-015-9584-2

Kiran, D., & Sungur, S. (2018). Science teachers' motivation and job satisfaction in relation to perceived school context. *Education and Science*, *43*(194), 61–80. https://doi.org/10.15390/EB.2018.7409

Kislyakov, P., Shmeleva, E., & Belyakova, N. (2019). Professional objectives of future STEM specialists. *Advances in Economics, Business and Management Research*, *79*, 102–105. https://download.atlantis-press.com/proceedings/iscfec-19/125906357

Klein, J. (2019). *Standard scores and raw scores and percentiles . . . oh my!* Central Institute for the Deaf. https://cid.edu/2019/05/20/standard-scores-and-raw-scores-and-percentilesoh-my/

Kolb, A. Y., & Kolb, D. A. (2017). Experiential learning theory as a guide for experiential educators in higher education. *Experiential Learning & Teaching in Higher Education*, *1*(1), 1–39.

Kolb, A. Y., & Kolb, D. A. (2018). Eight important things to know about the experiential learning cycle. *Australian Educational Leader*, *40*(3), 8–14.

https://learningfromexperience.com/downloads/research-library/eight-important-things-to-know-about-the-experiential-learning-cycle.pdf

Koopman, O. (2017). Phenomenology as a method in education research. In W. F. Pinar & J. L. Miller (Eds.), *Science education and curriculum in South Africa* (pp. 1–24). Palgrave Macmillan.

Kouni, Z., Koutsoukos, M. I., & Panta, D. (2018). Transformational leadership and job satisfaction: The case of secondary education teachers in Greece. *Journal of Education and Training Studies*, *6*, 158–168. https://doi.org/10.11114/jets.v6i10.3451

Krahenbuhl, K. S. (2016). Student-centered education and constructivism: Challenges, concerns, and clarity for teachers. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *89*(3), 97–105. https://doi.org/10.1080/00098655.2016.1191311

Kwon, H., Capraro, R. M., & Capraro, M. M. (2021). When I believe, I can: Success STEMs from my perceptions. *Canadian Journal of Science, Mathematics and Technology Education*, *21*, 67–85. https://doi.10.1007/s42330-020-00132-4

Lamm, A. J., Lamm, K. W., Rodriguez, M. T., & Owens, C. T. (2016). Examining leadership style influence on engagement in a national change process: Implications for leadership education. *Journal of Leadership Education*, *15*(4), 1–14. https://doi.org/10.12806/V15/I4/R1

Leasa, M., Corebima, A. D., & Batolona, J. R. (2020). The effect of learning styles on the critical thinking skills in natural science learning of elementary school students. *Ilkogretim Online - Elementary Education Online*, *19*(4), 2086-2097. https://doi.10.17051/ilkonline.2020.763449

Liu, L. (2016). Using generic inductive approach in qualitative educational research: A case study analysis. *Journal of Education and Learning*, *5*(2), 129–135. https://doi.org/10.5539/jel.v5n2p129

Male, T. (2016). Analysing qualitative data. In I. Palaiologou, D. Needham, & T. Male (Eds.), *Doing research in education: Theory and practice* (pp. 177–191). SAGE Publications.

Mand Labs. (2020). *Current state of STEM education in the US: What needs to be done?* https://www.mandlabs.com/current-state-of-stem-education-in-us-what-needs-to-be-done/

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *International Journal of STEM Education*, *6*(2), 1–16. https://doi.org/10.1186/s40594-018-0151-2

Masterson, J. (2016). Language, literacy, and Dewey: "Experience" in the language arts context. *The Nebraska Educator, 3, 47-63.* https://doi.org/10.13014/K25Q4T1RMcLeod, S. (2017). *Kolb's learning styles and experiential learning cycle*. Simply Psychology. https://www.simplypsychology.org/learning-kolb.html

McLeod, S. (2018a). *Jean Piaget's theory of cognitive development*. Simply Psychology. https://www.simplypsychology.org/piaget.html

McLeod, S. (2018b). *Lev Vygotsky*. Simply Psychology. https://www.simplypsychology.org/vygotsky.html

Meyer, M., & Norman, D. (2020). Changing design education for the 21st century. *Journal of Design, Economics, and Innovation*, *6*(1), 13–49. https://doi.org/10.1016/j.sheji.2019.12.002

Michels, B. I., & Eijkelhof, M. C. (2019). The development and implementation of an interdisciplinary STEM course for upper secondary schools. *Journal of the International*

Society for Design and Development in Education, *3*(12), 1–21. http://www.educationaldesigner.org/ed/volume3/issue12/article48/

Moallen, M., & Igoe, E. (2018, October 21–23). *Problem-based learning and computer-based scaffolds in distance education* [Paper presentation]. 15th International Conference on Cognition and Exploratory Learning in Digital Age, Budapest, Hungary. https://www.semanticscholar.org/paper/Problem-Based-Learning-and-Computer-Based-Scaffolds-Moallem-Igoe/ac29fec3882e73681f4631fa72f33f41d762f1b5

Morrow, J. (2020). *Science, technology, engineering, and math, including computer science*. U.S. Department of Education. https://www.ed.gov/stem

National Aeronautics and Space Administration. (2018). *Engineering design process*. www.nasa.gov

National Assessment Governing Board. (2015). *2015 science assessment*. https://www.nagb.gov/naep-results/science.html

National Assessment Governing Board. (2019). *2019 NAEP reading and mathematics*. https://www.nagb.gov/naep-results/naep-day-2019.html

National Assessment of Educational Progress. (2017). *2017 mathematics results*. https://www.nationsreportcard.gov/reading_math_2017_highlights/files/infographic_2018_math.pdf

National Assessment of Educational Progress. (2018). *NAEP and state assessments*. National Center for Education Statistics. https://nces.ed.gov/nationsreportcard/state/state_differences.aspx

National Assessment of Educational Progress. (2020). *About NAEP: A common measure of student achievement*. National Center for Education Statistics.

https://nces.ed.gov/nationsreportcard/about/

National Science & Technology Council. (2018). *Chartering a course for success: America's strategy for STEM education*. https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf

Neubauer, B. E., Witkop, C. T., & Varpio, L. (2019). How phenomenology can help us learn from the experiences of others. *Perspectives on Medical Education*, *8*(2), 90–97. https://doi.org/10.1007/s40037-019-0509-2

Newman, J., Dantzler, J., & Coleman, A. N. (2015). Science in action: How middle school students are changing their world through STEM service-learning projects. *Theory into Practice*, *54*, 47–54. https://doi.org/10.1080/00405841.2015.977661

Next Generation Science Standards. (2020). *Three dimensions of science learning*. https://www.nextgenscience.org/

Ngo, V. T. (2021). The impacts of integrated stem education on students' learning motivation. *Technium Social Sciences Journal*, *15*, 61-70. https://techniumscience.com/index.php/socialsciences/article/view/2289/896

Nowikowski, S. H. (2017). Successful with STEM? A qualitative case study of pre-service teacher perceptions. *The Qualitative Report*, *22*(9), 2312–2333. https://nsuworks.nova.edu/tqr/vol22/iss9/3/

Ntemngwa, C., & Oliver, S. (2018). The implementation of integrated science technology, engineering, and mathematics instruction using robotics in the middle school science classroom. *International Journal of Education in Mathematics, Science and Technology*, *6*(1), 12–40. https://doi.org/10.18404/ijemst.380617

Nugroho, K. Y., & Wulandari, D. F. (2017). Constructivist learning paradigm as the basis on learning model development. *Journal of Education and Learning*, *409*(4), 410–415. https://doi.org/10.11591/edlearn.v11i4.6852

Office of Innovation and Improvement. (2016). *STEM 2026: A vision for innovation in science, technology, engineering, and mathematics education*. http://www.air/org/system/files/downloads/report/STEM-2026-Vision-for-Innovation-September-2016.pd

Ostovar-Nameghi, S. A., & Sheikhahmadi, M. (2016). From teacher isolation to teacher collaboration: Theoretical perspectives and empirical findings. *Canadian Center of Science and Education*, *9*(5), 197–204. https://doi.org/10.5539/elt.v9n5p197

OwlGen. (2020). *Describe the role of education as an agent of social change?* https://www.owlgen.in/describe-the-role-of-education-as-an-agent-of-social-change/

Ozkan, G., & Topsakal, U. U. (2017). Examining students' opinions about STEAM activities. *Journal of Education and Training Skills*, *5*(9), 115–123. https://doi.org/10.11114/jets.v5i9.2584

Pascucci, M. (2016). Deweyan aesthetics as experiential education. *Journal of Philosophy & History of Education*, *66*(1), 1–11. http://www.journalofphilosophyandhistoryofeducation.com/jophe66_individual_files/PascucciJOPHE66.pdf

Pittinsky, T. L., & Diamante, N. (2015). Going beyond fun in STEM. *Phi Delta Kappan*, *97*(2), 47–51. https://doi.org/10.1177/0031721715610091

Poth, R. D. (2019). *The future of work: How do we prepare our students?* Getting Smart. https://www.gettingsmart.com/2019/04/the-future-of-work-how-do-we-prepare-our-students/

Preston, C. (2018, January 9). Most Americans say U.S. STEM education is middling, new poll finds. *The Hechinger Report*. https://hechingerreport.org/americans-say-u-s-stem-education-middling-new-poll-finds/

Raby, E. (2015, January 8). *STEM in the primary classroom: 4 ways educators are acclimating to STEM education*. https://www.nwea.org/blog/2015/stem-primary-classroom-4-ways-educators-acclimating-stem-education/

Reaves, S. J., & Cozzens, J. A. (2018). Teacher perceptions of climate, motivation, and self-efficacy: Is there really a connection. *Journal of Education and Training Studies*, *6*(12), 48–67. https://doi.org/10.11114/jets.v6i12.3566

Riegler, A. (2018). *Ernst von Glasersfeld*. Biography.com. http://vonglasersfeld.com/biography.shtml

Roche, R., & Manzi, J. (2019). Bridging the confidence gap: Raising self-efficacy amongst urban high school girls through STEM education. *American Journal of Biomedical Science & Research*, *5*(6), 452–454. https://doi.org/10.34297/AJBSR.2019.05.000964

Ryu, M., Mentzer, M., & Knobloch, N. (2019). Preservice teachers' experiences of STEM integration: Challenges and implications for integrated STEM teacher preparation. *International Journal of Technology and Design Education*, *29*, 493–512. https://doi.org/10.1007/s10798-018-9440-9

SaiRaman, H. (2019). *5 goal setting steps to achieve your dream goals*. Thrive Global. https://thriveglobal.com/stories/5-goal-setting-steps-to-achieve-your-dream-goals/

Sanjari, M., Bahramnezhad, F., Fomani, F. K., Shoghi, M., & Cheraghi, M. A. (2014). Ethical challenges of researchers in qualitative studies: The necessity to develop a specific guideline. *Journal of Medical Ethics and History of Medicine*, *7*, 14.

https://www.ncbi.nlm.nih.gov/pubmed/25512833

Sarı, U., Alıcı, M., & Şen, Ö. (2018). The effect of STEM instruction on attitude, career perception and career interest in a problem-based learning environment and student opinions. *Electronic Journal for Research in Science & Mathematics Education*, *22*(1), 1–21. http://ejse.southwestern.edu/article/view/17861

Saunders, B., Sim, J., Kingstone, T., Baker, S., Waterfield, J., Bartlam, B., Burroughs, H., & Jinks, C. (2018). Saturation in qualitative research: Exploring its conceptualization and operationalization. *Quality & Quantity*, *52*(4), 1893–1907. https://doi.org/10.1007/s11135-017-0574-8

Saw, G., Schneider, B., Frank, K., Chen, I., Keesler, V., & Martineau, J. (2017). The effect of being labeled as a persistently lowest achieving school: Regression discontinuity evidence on consequential school labeling. *American Journal of Education*, *123*(4), 585–613. https://www.journals.uchicago.edu/doi/abs/10.1086/692665?af=R&mobileUi=0&

Schleicher, A. (2018). Educating learners for their future, not our past. *ECNU Review of Education*, *1*(1), 58–75. https://doi.org/10.30926/ecnuroe2018010104

Seixas, B. V., Smith, N., & Mitton, C. (2017). The qualitative description approach in international comparative studies: Using online qualitative surveys. *International Journal of Health Policy and Management*, *7*(9), 778–781. https://doi.org/10.15171/ijhpm.2017.142

Selbe, S. (2016, May 4). South Carolina ranks in bottom 10 states for test scores. *The State Newspaper*. https://www.thestate.com/news/databases/article75523192.html

Sharkins, K., Newton, A., Causey, C., & Ernest, J. M. (2017). Flipping theory: Ways in which children's experiences in the 21st century classroom can provide insight into the theories of Piaget and Vygotsky. *International Journal of Early Childhood Education Care*, *6*, 11–18. https://doi.org/10.37134/saecj.vol6.2.2017

Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education. *International Journal of STEM Education*, *4*(13), 1–16. https://doi.org/10.1186/s40594-017-0068-

Smith, L. (2017). *A brief biography of Jean Piaget*. John Piaget Society. http://www.piaget.org/aboutPiaget.html

South Carolina Department of Education. (2019a). *South Carolina College- and Career-Ready Assessments: Score report user's guide*. https://ed.sc.gov/tests/tests-files/sc-ready-files/sc-ready-spring-2019-score-report-users-guide/#:~:text=Meets%20Expectations%20%E2%80%93%20The%20student%20meets,the%20grade%2Dlevel%20content%20standards

South Carolina Department of Education. (2019b). *2018 South Carolina test scores*. https://ed.sc.gov/data/test-scores/state-assessments/

South Carolina Department of Education. (2021). *Standards and learning.* https://ed.sc.gov/instruction/standards-learning/

Stahnke, R., Schueler, S., & Roesken-Winter, B. (2016). Teachers' perception, interpretation, and decision-making: A systematic review of empirical mathematics education research. *ZDM Mathematics Education*, *48*, 1–27. https://doi.org/10.1007/s11858-016-0775-y https://doi.org/10.4212/cjhp.v68i3.1456

Tan, J. P., Choo, S. S., Kang, T., & Liem, G. A. (2017). Educating for twenty-first century competencies and future-ready learners: Research perspectives from Singapore. *Asian*

Pacific Journal of Education, *37*(4), 425–436. https://doi.org/10.1080/02188791.2017.1405475

Taştan, S. B., Davoudi, S. M. M., Masalimova, A. R., Bersanov, A. S., Kurbanov, R. A., Boiarchuk, A. V., & Pavlushin, A. A. (2018). The effects of teacher's efficacy and motivation on student's academic achievement in science education among secondary and high school students. *Journal of Mathematics, Science and Technology Education*, *14*(6), 2353–2366. https://doi.org/10.29333/ejmste/89579

TES Editorial. (2018). *What is pedagogy?* https://www.tes.com/news/what-is-pedagogy-definition

Theofanidis, D., & Fountouki, A. (2018). Limitations and delimitations in the research process. *Perioperative Nursing*, *7*(3), 155–162. https://doi.org/10.5281/zenodo.2552022

Thiele, T., Singleton, A., Pope, D., & Stanistreet, A. (2016). Predicting students' academic performance based on school and socio-demographic characteristics. *Studies in Higher Education*, *41*(8), 1424–1446. https://doi.org/10.1080/03075079.2014.974528

Ugras, M. (2018). The effects of STEM activities on STEM attitudes, scientific creativity and motivational beliefs of the students and their views on STEM education. *Online Journal of Educational Services*, *10*(5), 165–182. https://doi.org/10.15345/iojes.2018.05.012

Umanailo, M. (2019). *Overview phenomenological research*. https://doi.org/10.31226/osf.io/ntzfm

Unfried, A., Faber, M., Stanhope, D. S., & Wiebe, E. (2015). The development and validation of a measure of student attitudes towards science, technology, engineering and math (S-STEM). *Journal of Psychoeducational Assessment*, *33*(7), 622–639. https://doi.org/10.1177/0734282915571160

U.S. Department of Education. (2015). *Data tools: NAEP data explorer*. National Assessment of Educational Progress. https://www.nationsreportcard.gov/ndecore/xplore/NDE

U.S. Department of Education. (2019). *Data tools: State profiles*. National Assessment of Educational Progress. https://www.nationsreportcard.gov/profiles/stateprofile?chort=2&sub=MAT&sj=AL&sfj=NP&st=MN&year=2019R3

VanGronigen, B. A., & Meyers, C. V. (2019). How state education agencies are administering school turnaround efforts: 15 years after No Child Left Behind. *Educational Policy*, *33*(3), 423–452. https://doi.org/10.1177/0895904817691846

van Manen, M. (2014). *Phenomenology of practice*. Routledge. https://doi.org/10.4324/9781315422657

Vaughn, P., & Turner, C. (2015). Decoding vs. coding: Analyzing qualitative text through thematic coding and survey methodologies. *Journal of Library Administration*, *56*(1), 41–51. https://doi.org/10.1080/01930826.2015.1105035

Verenna, A. A., Noble, K. A., Pearson, H. E., & Miller, S. M. (2018). *Role of comprehension on performance at higher levels of Bloom's taxonomy: Findings from assessments of healthcare professional students*. https://doi.org/10.1002/ase.1768

Walker, W. S., Moore, T. J., Goosey, S. S., & Sorge, B. H. (2018). Frameworks to develop integrated STEM curricula. *K–12 STEM Education*, *4*(2), 331–339.

Watson, M. K., Pelkey, J., Noyes, C., & Rodger, M. O. (2019). Using Kolb's learning cycle to improve student sustainability knowledge. *Sustainability*, *11*(4602), 1–19. https://doi.org/10.3390/su11174602

Wexler, N. (2020, January 13). Teachers think kids need science and social studies—but still focus on reading and math. *Forbes*. https://www.forbes.com/sites/nataliewexler/2020/01/13/teachers-think-kids-need-science-and-social-studies-but-still-focus-on-reading-and-math/#33626c62318f

White, S. (2018, February 21). What is transformational leadership? A model for motivating innovation. *CIO*. https://www.cio.com/article/3257184/what-is-transformational-leadership-a-model-for-motivating-innovation.html

Widya, R. R., & Rahmi, Y. L. (2019). STEM education to fulfil the 21st century demand: A literature review. *Journal of Physics: Conference Series, 1317*, 1-8. https://doi.10.1088/1742-6596/1317/1/012208

Winangun, M. M., & Kurniawan, D. (2019, June). *The barriers of school using subject design curriculum in implementing STEM education: Perspectives of science teacher* [Paper presentation]. International Conference on Mechanical and Electrical Technologies, Nanjing, China. https://doi.org/10.1145/3341042.3341053

WLTX. (2020, January 20). *South Carolina ranked among least educated states in recent study*. https://bit.ly/2K35jjv

Wolgemuth, J. R., Hicks, T., & Agosto, V. (2017). Unpacking assumptions in research synthesis: A critical construct synthesis approach. *Educational Researcher*, *46*(3), 131–139. https://doi.org/10.3102/0013189X17703946

Woodard, J. (2019). Rotten STEM: How technology corrupts education. *American Affairs*, *3*(3), 82–96. https://americanaffairsjournal.org/2019/08/rotten-stem-how-technology-corrupts-education/

Xie, Y., Fang, M., & Shauman, K. (2015). STEM education. *Annual Review of Sociology*, *41*, 331–357. https://doi.org/10.1146/annurev-soc-071312-145659

Yanez, G. A., Thumlert, K., de Castell, S., & Jenson, J. (2019). Pathways to sustainable futures: A "production pedagogy" model for STEM education. *Futures*, *108*, 27–36. https://doi.org/10.1016/j.futurws,2019.02.021

Yildirim, B., & Türk, C. (2018). Opinions of secondary school science and mathematics teachers on STEM education. *World Journal on Educational Technology: Current Issues*, *10*(1), 52–60.

Yin, R. K. (2018). *Case study research and applications* (6th ed.). SAGE Publications.

Young, B., & Hren, D. (2017). *Introduction to qualitative research methods* [PowerPoint slides]. http://miror-ejd.eu/wp-content/uploads/sites/34/2017/03/Introduction-to-qualitative-research-methods.compressed.pdf

Young, M. D., Winn, K. M., & Reedy, M. A. (2017). The every student succeeds act: Strengthening the focus on educational leadership. *Educational Administration Quarterly*, *53*(5), 705-726. https://doi.10.1177/0013161X17735871

Zakaria, F. (2015, March 6). Why America's obsession with STEM education is dangerous. *The Washington Post*. https://www.washingtonpost.com/opinions/why-stem-wont-make-us-successful/2015/03/26/5f4604f2-d2a5-11e4-ab77-9646eea6a4c7_story.html

Zaloom, C. (2019, September 10). STEM is overrated. *The Atlantic*. https://www.theatlantic.com/ideas/archive/2019/09/college-not-job-prep/597487/

Zhang, Y., Zhang, J., & Darko, A. (2018). How does transformational leadership promote innovation in construction? The mediating role of innovation climate and the multilevel moderation role of project requirements. *Sustainability*, *10*(5), 1–19. https://doi.org/10.3390/su10051506

Appendix A

Permission to Use Figure 1

Back | Archive | Move | Delete | Spam | •••

Re: permission to use graphic

Yahoo/Inbox

[redacted]>

To: Marsha Neal

Wed, Apr 22 at 9:59 AM

Hi Marsha,

Please feel free to use the image(s). Good luck with your writing and stay safe.

Best wishes,

[redacted]

On Wed, 22 Apr 2020, 14:20 Marsha Neal, <[redacted]> wrote:

Good morning. I am in the process of writing my dissertation through American College of Education. I am writing chapter 2 - Literature Review- and I am describing the theoretical frameworks around my study. I am requesting permission to use the graphics from your online article in my dissertation.

Kolb's Learning Styles and Experiential

Kolb's Learning Styles and Experiential Learning Cycle

3y Saul McLeod, updated 2017

Thank you for your consideration in this matter and I look forward to hearing back from you on this matter.

Marsha Neal

Appendix B

Second Approval from Institutional Review Board

RE: change in dissertation site for research

Yahoo/Inbox

ACE IRB [redacted]

To: Marsha Neal, ACE IRB

Thu, Oct 1 at 1:13 PM

Hi Marsha,

Your changes are approved; I will save a copy of these documents to her IRB review folder. Please share this approval with your chair.

Thanks!

[redacted]

Interim Chair, Institutional Review Board

[redacted]

American College of Education

101 W Ohio, Suite 1200, Indianapolis, IN 46204

Phone: 817-437-1296

Email: [redacted]

ace.edu

AMERICAN COLLEGE of EDUCATION

Certified B Corporation

Appendix C

Third Approval from Institutional Review Board

RE: additional approval due to adding another school

Yahoo/Inbox

ACE IRB <[redacted]

Fri, Oct 16 at 3:14 PM

To: Marsha Neal, ACE IRB, [redacted]

Hi Marsha,

Your changes are approved; I will save a copy of these documents to the IRB review folder.

[redacted]

Interim Chair, Institutional Review Board

American College of Education

Appendix D

Questionnaire Questions

1. Pertaining to STEM, how is your teaching practice continually improving?
2. How is STEM being implemented at your school?
3. How does STEM help both high and low achieving students?
4. How do students develop problem-solving skills through the implementation of STEM?
5. What type of activities with a real-world context do the students complete?
6. How do students use the strategies from STEM in other subject areas?
7. How are students able to reason both abstractly and quantitatively through STEM?
8. What variety of assessments are used throughout the year to evaluate progress?
9. What types of academic achievements in other areas have been seen, using what the students learned in STEM?
10. How does the school promote higher-order thinking, analysis, synthesis and evaluation of ideas and information?

Appendix E

Interview Questions

1. In your own words, define STEM education?
2. What are some examples of real-world outcomes for students who have an effective science or STEM education?
3. What does a classroom which integrates STEM looks like and feels like and how can STEM be integrated across content areas?
4. What are some examples of collaboration between science and non-science teachers in your school?
5. What are some partnerships (e.g., with community, non-profits, universities, businesses, industry, etc.), if any, your school has formed to help further STEM education?
6. How can effective STEM education be increased at your school?
7. What are some challenges faced on the way to supporting STEM education?
8. What are differences noticed pertaining to student perseverance in terms of STEM education?
9. How has STEM education improved student achievement?
10. How are the students challenged in coursework with STEM?

Appendix F

Research Participant Recruitment Letter

Date

Dear:

I am writing to let you know about an opportunity to participate in a dissertation research study about perceptions of student teaching. I am a doctoral student at American College of Education. The information was used for my dissertation research related to The Perception of STEM Education on Middle Schools: A Case Study. You have been identified as a possible participant since you are currently teaching in one of the three middle schools, I am using in my research study, you have at least three years' teaching experience and you have taught at the school for at least two years.

The purpose of the research study is to explore the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in Southeastern South Carolina and to identify how the programs make the three schools successful based on the state standardized tests of South Carolina. As I have mentioned, you have been identified as a possible participant for the study. Agreement to be contacted for more information does not obligate you to participate in the study. Your participation in the study is voluntary. If you do not wish to participate, you may withdraw at any time.

I may publish the results of the study; however, I will not use your name or share any information you provided. Your information will remain confidential. If you would like additional information about the study, please contact me.

Principal Investigator:
Email:
Phone:

Dissertation Chair:
E-mail:
Phone:

Thank you again for considering this dissertation research opportunity.

Sincerely,

Appendix G

School A Permission Email

request to use school for dissertation research

Marsha Neal <[redacted]
to [redacted]

Tue, Sep 29, 8:23 AM (21 hours ago)

Good morning. I am starting my dissertation research through the American College of Education and I am doing a qualitative case study on the perception of STEM education in 2 schools in the LowCountry. I would love to use [redacted]s one of the schools, since it is a school of science, as one of my schools, as well as a middle school in [redacted].

My study will consist of interviewing teachers from different subject areas, Related Arts teachers, instructional coaches and administrators on perceptions, effectiveness, etc. of STEM (NO STUDENTS).

The goal of this research study is to understand the perceptions of administrators, instructional coaches, and teachers on the impact of science, technology, engineering, and mathematics initiatives on middle school students.

I am attaching the participant consent form, so you can see what I am asking of the participants. Each participant must have at least 3 years experience in education and at least 2 completed years at [redacted]
The only things that will be needed from the participants after signing the consent form is to do an online 10 question questionnaire and participate in a virtual interview that will last no more than one hour.

Please let me know if your school would be willing to participate. Once I hear back from you, I will let you know what the next steps are.

Thanks!

5:40 AM

[redacted] & Research Project Inbox ×

[redacted]
to me

Tue, Sep 29, 8:45 PM (8 hours ago)

Hi Marsha.

My name is [redacted] and I'm one of the Instructional Coaches at [redacted] I'm happy to help with your research project and be your point of contact.

Please let me know what my next steps should be in order to best help you.

Thanks!

[redacted]

Instructional Coach

[redacted]

Appendix H

School B Permission Email

Good evening. I am in the process of starting my dissertation through the American College of Education and I am doing a qualitative descriptive study on the impact that STEM education has on 2 schools in the LowCountry. I would love to do [redacted] as one of the schools, since they are a STEAM school, along with one of the middle schools in Charleston county.

My study will consist of interviewing teachers from each core subject, Related Arts teachers, one instructional coach and one administrator on perceptions, effectiveness, etc. of STEM (NO STUDENTS).
My guiding research questions are as follows:
Research Question One: What is the perception of school administrators, instructional coaches and sixth through eighth grade teachers at two middle schools in Southeast South Carolina who teach science, technology, engineering and math skills based on the State's Standardized Tests?

Research Question Two: How do participants describe the learning experiences for students in science, technology, engineering and mathematics (STEM) related courses and educational programs at two middle schools in Southeast South Carolina?

Research Question Three: What strategies do participants perceive to be effective in helping students achieve academic success through science, technology, engineering and mathematics (STEM) education in two middle schools in Southeastern South Carolina?

Please let me know if your school would be willing to participate.

Thanks!
Marsha Neal

Sent By: Marsha Neal

Sent From: [redacted]

RE: use of school site for dissertation research Inbox ×

[redacted] Feb 11, 2020, 1:28 PM (4 days ago)

to me

Good afternoon,
I am fine with this, we are not a full fledged STEAM school nor an accredited STEM school, so you may want to touch base with a school who is as well.

[redacted]

Principal

[redacted]

Appendix I

School C Permission Email

request to use school for part of my dissertation research Inbox x

[redacted]

Marsha Neal <[redacted]> Oct 12, 2020, 1:02 PM (2 days ago)

to [redacted]

Good afternoon. I am working on my dissertation research through the American College of Education and I am doing a qualitative case study on the perception of STEM education in 3 schools in South Carolina. I would love to use [redacted] as one of the schools, since you have had a school-wide STEM initiative (at least prior to COVID).The other 2 schools involved are middle schools in [redacted]

My study consists of interviewing teachers from different subject areas, Related Arts teachers, instructional coaches, and administrators on perceptions, effectiveness, etc. of STEM (NO STUDENTS).

The goal of this research study is to understand the perceptions of administrators, instructional coaches, and teachers on the impact of science, technology, engineering, and mathematics initiatives on middle school students.

I am attaching the participant consent form, so you can see what I am asking of the participants. Each participant must have at least 3 years of experience in education and at least 2 completed years at [redacted]

The only things that will be needed from the participants after signing the consent form are to do an online 10 question questionnaire through SurveyMonkeyand participate in a virtual interview that will last no more than 45 minutes.

Please let me know if your school would be willing to participate. Once I hear back from you, I will let you know what the next steps are.

Marsha Neal, M.Ed., NBCT

6th-grade Math/Science Teacher

[redacted] Wed, Oct 14, 10:09 AM (1 day ago)

to me

Marsha,

Sorry for the late reply. We would be happy to participate.

[redacted]

Principal

[redacted]

...

[redacted] Marsha Neal <[redacted]> Wed, Oct 14, 11:18 AM (1 day ago)

to [redacted]

Thanks so much!!! Is there a point of contact person you want me to contact, so I don't have to bother you? That is what the other 2 schools did.
I will need a list of administrators, instructional coaches and teachers who have been completed 2 years at your school, so I can send them out a participation recruitment letter.

Marsha Neal, M.Ed., NBCT
6th-grade Math/Science Teacher
[redacted]

LEVEL 1 CERTIFIED Educator Google for Education

IRB Approved Dissertation

[redacted] Oct 14, 2020, 11:32 AM (1 day ago)

to [redacted]me ▾

Marsha,

I have attached Alice Kelley to this email. Alice is our assistant principal who has lead our STEM program and is a wealth of knowledge. She can assist you with this process.

[redacted]

[redacted]
Principal
[redacted]

Appendix J

Informed Consent Form

Prospective Research Participant:
Read this consent form carefully and ask as many questions as you like before you decide whether or not you want to participate in this research study. You are free to ask questions at any time before, during, or after your participation in this research.

Project Information:
The goal of this research study is to explore the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in Southeastern South Carolina.

Project Title: The Perception of STEM Education on Middle Schools: A Case Study

Lead Researcher	**Institution** American College of Education
Email	**Phone number**

Lead Researcher's Faculty Member:
Organization and Position: American College of Education, Dissertation Chairperson

Email	**Phone number**

Introduction
I am a student at American College of Education. I am doing research under the guidance and supervision of, Dissertation Chairperson. I will give you some information about the project and I invite you to be part of this research. Before you decide, you can talk to anyone you feel comfortable with about the research. Please ask me any questions as we go through the information and I will explain. If you have questions later, you can ask them then.

Purpose of the Research
The purpose of the qualitative study is to explore the perceptions of the effectiveness of STEM initiatives on student academic success at three middle schools in Southeastern South Carolina.

Brief Description of Methodology
This research will involve your participation in completing an open-ended questionnaire and an interview will take place either in person, via phone, or virtually, and will last about one hour.

Participant Selection
You are being invited to take part in this research because your experience as either an administrator, instructional coach, or teacher at one of the chosen middle schools. You also have at least 3 years' experience in education and at least 2 years' experience at your present school.

Voluntary Participation
Your participation in this research is entirely voluntary. It is your choice whether or not to participate. The choice you make will have no bearing on your job or on any work-related evaluations or reports. You may change your mind later and stop participating even if you agreed to participate earlier.

Procedures
I am asking you to help me learn more about how educators perceive the effectiveness of STEM education in middle schools. I am inviting you to take part in this research project. If you accept, you were asked to participate in an interview. The semi-structured questions will focus on the experiences perceived by the educators.

Duration
The research takes place over two months. During that time, I will email you the questionnaire through SurveyMonkey for you to complete. After the questionnaire is complete, I will conduct the interview with you, either in person, via phone, or virtually; whichever method you choose. The interview will last about one hour.

Risks
You do not have to answer any question or take part in the discussion if you do not wish to do so. You do not have to give any reason for not responding to any question.

Benefits
While there is no direct financial benefit to you, your participation is likely to help us provide data which will inform the state department and other schools of the impact science, technology, engineering, and mathematics initiatives can have on middle school students.

Reimbursements
There is no direct benefit to each participant.

Confidentiality
I will not share information about you or anything you say to anyone outside of the research team. The information I collect were kept in a locked safe. Any information about you will have a number on it instead of your name. Only I will know what your number is, and I will secure the information.

Sharing the Results
Each participant will receive a summary of the research findings. I hope to publish the results so other interested people may learn from the research.

Right to Refuse or Withdraw
Reconfirm participation is voluntary and includes the right to withdraw at any time.

Who to Contact
If you have any questions, you can ask them now or later. If you wish to ask questions later, you

may contact, cell or email [redacted] or [redacted]. This research plan has been reviewed and approved by the Institutional Review Board of American College of Education. This is a committee whose role is to make sure research participants are protected from harm. If you wish to ask questions of this group, email IRB@ace.edu and/or you may contact my Dissertation Chairperson, his contact information is [redacted] or his email is [redacted].

Certificate of Consent

By signing this form, you agree you understand the nature of the study, the possible risks to you as a participant, and how your identity were kept confidential. When you sign this form, it means you are 18 years old or older and you give permission to volunteer as a participant in the study described here.

I have read the information about this study, or it has been read to me. I have had the opportunity to ask questions about the study, and any questions have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

A copy of this informed consent letter was given to the participant.

Print or Type Name of Participant: ____________________________

Signature of Participant: ____________________________

Date: ______________

Appendix K

Communication Emails with School A Contact Person

[redacted] & Research Project

[redacted] Tue, Sep 29, 2020, 8:45 PM

to me

Hi Marsha.

My name is [redacted] and I'm one of the Instructional Coaches at [redacted] I'm happy to help with your research project and be your point of contact.

Please let me know what my next steps should be in order to best help you.

Thanks!

[redacted]

--

[redacted]

Instructional Coach

[redacted]

Marsha Neal <[redacted] Wed, Sep 30, 2020, 5:51 AM

to S[redacted]

Hi! Thanks so much for being my point of contact. I will need to know the names of the teachers who have at least 3 years of educational experience and have completed at least 2 years at [redacted] the directory page on the school's website is current, I can look there and you can send me the names of the teachers who have not been there at least 2 years, so I can take them off of my list. The list would include administrators, instructional coaches, and teachers of all subjects, including related arts.

My understanding is not many people leave JZMS often, so it might be pretty much the entire staff. If that is the case, I will pull the names from the website. I would like you to send an email to all staff, letting them know they will be getting an email from me inviting them to be a participant in my dissertation study research, so they do not think it is a spam email.

Thanks again for your help!

Marsha Neal, M.Ed., NBCT
6th-grade Math/Science Teacher
[redacted]

[redacted]

to [redacted], me

Good morning!

You are absolutely right - great people don't want to leave [redacted]

The following teachers either don't have the required years in teaching and/or the required number of years in our building:

[redacted]

Appendix L

Communication Emails with School B Contact Person

[redacted] Fri, Sep 18, 2020, 7:51 AM
to me

Good Morning Ms. Neal,

[redacted] has asked me to follow up with you regarding your request. Let me know how I may help you.

Best regards,

[redacted]
Office Manager
[redacted]

Marsha Neal <[redacted]> Sep 18, 2020, 8:25 AM
t[redacted]

Good morning!!!! Thank you so much for your help!!

What I am in need of is a list of administrators, instructional coaches & teachers (names & email addresses) who have at least 3 years teaching experience & who have been at [redacted] for at least 2 years (not counting this year).
I will then email them a recruitment letter asking them to volunteer to be a part of my dissertation study.

I greatly appreciate it!!!

Marsha Neal

Marsha Neal [redacted] Sep 22, 2020, 8:05 AM
to [redacted]

Good morning Ms. Paquin-Groth!
I looked at the teacher bios on the [redacted] webpage and was able to come up with the list I needed. I would like to email out the recruitment letter this afternoon, asking the teachers if they would be willing to participate. Is it possible for the principal or yourself to send an email out to everyone stating they might be receiving an email from me, so they know what it is before they get the email from me?

[redacted] Sep 22, 2020, 8:52 AM
to me

Good Morning,

If you would like to send me the list of teachers I would be happy to email them to be on the lookout for your communication.

Best,

[redacted]

Marsha Neal <[redacted] Sep 22, 2020, 8:59 AM
to [redacted]

Awesome!! Thank you so much!
Here is the list:

[redacted]

Appendix M

Communication Emails with School C Contact Person

[redacted] Oct 14, 2020, 11:32 AM

to [redacted] me

Marsha,

I have attached[redacted]o this email. [redacted] is our assistant principal who has lead our STEM program and is a wealth of knowledge. She can assist you with this process.

[redacted]
Principal
[redacted]

From: Marsha Neal <[redacted]
Sent: Wednesday, October 14, 2020 11:19 AM
To: [redacted]
Subject: Re: request to use school for part of my dissertation research

Thanks so much!!! Is there a point of contact person you want me to contact, so I don't have to bother you? That is what the other 2 schools did.
I will need a list of administrators, instructional coaches and teachers who have been completed 2 years at your school, so I can send them out a participation recruitment letter.

Marsha Neal, M.Ed., NBCT

Marsha Neal <[redacted] Oct 14, 2020, 11:45 AM

to [redacted]

Hi! I am excited to use your school as part of my dissertation research. I will need a list of administrators, teachers, and instructional coaches who have at least 3 years of teaching experience completed and at least 2 years of experience completed a[redacted]
I think the easiest way to do this is to send me a list of teachers who do not fit these criteria (especially the time at DuBose) and I can look at your school directory and contact the ones that are not on your list.

Please let me know if you have any questions.
Marsha Neal, M.Ed., NBCT
6th-grade Math/Science Teacher
[redacted]

[redacted] Oct 16, 2020, 10:19 AM

to me

Good morning Mrs. Neal –
The following individuals do not meet the 2 years at [redacted] criteria. I'm going to notify our staff that you may be reaching out so they will not think they are being spammed ☺ Please let me know if you need my help in any way. I'm extremely passionate about STEM and PBL and have been involved in this area for quite some time. I would love for you to share your findings upon completion of your dissertation.
Happy Friday! I hope you have a wonderful weekend!!
[redacted]

Appendix N

Demographic Questionnaire

1. What is your first name?
2. What is your last name?
3. What school are you employed at?
4. How long have you been in education?
5. How long have you been at your current school?
6. What is your role at your school?

Appendix O

T-STEM Survey Permission for Questionnaire Questions

Friday Institute S-STEM and T-STEM Surveys

Yahoo/Inbox

AA [redacted]

Jan 21 at 2:27 PM

Thank you for your interest in using our evaluation instruments. These evaluation instruments were identified, modified, or developed through support provided by the Friday Institute. The Friday Institute grants you permission to use these instruments for educational, non-commercial purposes only. You may use an instrument "as is", or modify it to suit your needs, but in either case you must credit its original source. By using this instrument, you agree to allow the Friday Institute to use the de-identified data collected for additional validity and reliability analysis. You also agree to share with the Friday Institute publications, presentations, evaluation reports, etc. that include data collected and/or results from your use of these instruments. The Friday Institute will take appropriate measures to maintain the confidentiality of all data.

The STEM surveys (as pdfs) can be accessed and downloaded from here: go.ncsu.edu/fisstemandtstemsurveys. Please feel free to contact me if you have any further questions or inquiries related to the S-STEM and T-STEM surveys. Thank you.

Regards,

[redacted]

MISO Project

Friday Institute for Educational Innovation

North Carolina State University

1890 Main Campus Dr.

Raleigh, NC 27606

[redacted]

Re: Friday Institute S-STEM and T-STEM Surveys Yahoo/Sent

[redacted] **Marsha Neal** <[redacted] Fri, Feb 21, 2020 at 3:19 PM

To: [redacted]

Thank you for your response! Do you by chance have any similar questionnaires that have open-ended questions?

Marsha Neal

Sent from Yahoo Mail for iPhone

> On Tuesday, January 21, 2020, 2:27 PM, [redacted] wrote:
>
> Thank you for your interest in using our evaluation instruments. These evaluation instruments were identified, modified, or developed through support provided by the Friday Institute. The Friday Institute grants you permission to use these instruments for educational, non-commercial

Permission to use T-STEM items Yahoo/Inbox

E W [redacted] Tue, May 25 at 11:24 AM

Marsha Neil,
This is in response to your request for confirmation that you have permission to use items from the T-STEM survey instrument. As lead developer of this instrument, I give you permission to use items from the T-STEM. The only request is that you appropriately cite the origin of the original items:

Friday Institute for Educational Innovation (2012). *Teacher Efficacy and Attitudes Toward STEM Survey-XXX Teachers*, Raleigh, NC: Author.

'XXX' would be filled in with the version of the instrument you are using (e.g., Science).

[redacted]

--
[redacted]
Professor, Dept. of Science, Technology, Engineering, and Mathematics Education
Senior Research Fellow, Friday Institute for Educational Innovation
[redacted]

Appendix P

Field-Testing of Subject-Matter Experts

request to be a subject matter expert for dissertation Inbox x

Marsha Neal [redacted]

Sat, Feb 29, 7:36 AM (1 day ago)

Good evening. My name is Marsha Neal and I am currently working on my dissertation through American College of Education. The title of my dissertation is:The Impact of STEM Education on Middle Schools in Southeastern South Carolina - A Qualitative Phenomenological Study

I am in the process of field testing my interview questions and my online questionnaire questions for my dissertation. I would greatly appreciate it if you could take the time to look over both sets of questions that are attached to this email and choose 10 interview questions and 10 online questionnaire questions that you believe aligns best with my study and research questions.

For agreeing to be subject matter expert for my questions, I will acknowledge you by name in my dissertation on my acknowledgements page as being one of the subject matter experts.

Here are the guiding research questions for my study:

Research Question One: What is the perception of school administrators, instructional coaches and 20 sixth through eighth grade teachers at two middle schools in Southeast South Carolina who teach science, technology, engineering and math (STEM) skills based on the State's Standardized Tests?

Research Question Two: How do educators describe the experiences students obtain while participating in (STEM)-related courses and educational programs at two middle schools in Southeast South Carolina? **Research Question Three**: What strategies do educators perceive to be effective in helping students achieve academic success through science, technology, engineering and mathematics (STEM) education in two middle schools in Southeastern South Carolina?

If you are willing to participate, please reply back noting the question number of 10 interview and 10 questionnaire questions that you believe should be used in my dissertation.

If you cannot participate, please let me know as quickly as possible so I can locate another volunteer.

Thank you so much for your consideration in this matter.

--
Marsha Neal, M.Ed., NBCT
6th grade math/science Teacher
[redacted]

[redacted]
to me
Fri, Feb 28, 12:22 PM

Some questions were similar. I tried to take the best and most applicable ones to your study. Questionnaire- 1, 2, 8, 9, 10, 11, 13, 15, 16, 19 Interview- 1, 2, 3, 4, 7, 12, 13, 15, 17, 20

[redacted]
Marsha Neal [redacted]
to [redacted]
Fri, Feb 28, 12:23 PM

Thanks!

[redacted]
to me
Feb 28, 2020, 1:57 PM

Hello Marsha,

Congratulations on your dissertation! After reviewing the two documents, I believe the following should be used.

Interview Questions:
1, 3, 4, 5 (and maybe add "what constitutes as 'quality' STEM education" , 7, 9, 11, 12,17, 19.
As a heads up, #2 and #16 are the same.

Questionnaire Questions:
2,4,5,7,10,11,16,17,18,19

Let me know if I can be of further assistance!
[redacted]

[redacted]
to me
Mar 4, 2020, 6:05 AM

Please see my selections in blue. Thanks so much for asking for my input!

[redacted]
Science Instructional Specialist
Curriculum & Instruction
[redacted]

Interview Questions

1. In your own words, how would you define STEM education?
2. What are some examples of real-world outcomes for students who have an effective science or STEM education?
3. What do you think a classroom that integrates STEM looks like and feels like?
4. What are some ways STEM can be integrated across content areas?
5. In general, what do you think is needed to provide quality STEM education?
6. What are your non-science peers' perceptions on STEM education and why do you think this?
7. What are some examples of collaboration between science and non-science teachers in your school?
8. Why is understanding STEM education important to you?
9. What are some partnerships (e.g. with community, non-profits, universities, businesses, industry, etc.), if any, that your school has formed to help further STEM education?
10. What science teaching and learning practices are expected by teachers to utilize in the classroom?
11. How do you feel you would be able to increase effective STEM education at your school?
12. What are some challenges that you, personally, face on the way to supporting STEM education?
13. What are some challenges that your school faces when supporting STEM education?
14. Many schools have common resources. Please list some key resources you have at your school that support STEM education.
15. What do you feel YOU need to better support STEM education?
16. What are some examples of real-world outcomes for students who have an effective science or STEM education?
17. How has STEM education improved student achievement?
18. How has STEM education been a topic of discussion in your district and school?
19. Describe the students' relationships with, and a sense of ownership over, their learning experiences?
20. How do you challenge the students in their coursework with STEM?

Questionnaire Questions

1. How do you continually improve your teaching practice when it comes to STEM?
2. How is STEM being implemented at your school?
3. When a student has a difficulty understanding a STEM concept, what steps do you take?
4. How does STEM help students high achieving students?
5. How does STEM help low achieving students?
6. How does the use of technology enable students to communicate and collaborate?
7. What types of technology-enhanced projects that approach real-world applications of technology are utilized?
8. How do students develop problem-solving skills through the implementation of STEM?
9. What type of activities with a real-world context do you have the students complete?

---

10. How do students use the strategies from STEM in other subject areas?
11. How are students able to reason both abstractly and quantitatively through STEM?
12. How are students encouraged to do their best?
13. How do students include others' perspectives when making decisions?
14. How is the engineering design process implemented?
15. How do you take responsibility for all students' learning?
16. What variety of assessments do you use throughout the year to evaluate progress?
17. How do you empower students?
18. How have you seen academic achievements in other areas, using what the students learned in STEM?

19. How do you promote higher-order thinking, analysis, synthesis and evaluation of ideas and information?

20. How do you ensure that your students manage their time wisely?

[redacted]

Mar 16, 2020, 12:29 PM

to me

Interview: 2, 3, 4, 5, 9, 10, 13, 15, 17, 18

Questionnaire: 2, 4, 5, 6, 7, 8, 9, 10, 11, 18

--

[redacted]

Assistant Principal

[redacted]

[redacted]

Sat, Feb 29, 4:23 PM

to me

Hey Marsha,

Attached are my recommendations. Thanks for including me!

Best wishes,

[redacted]

[redacted]

Executive Director, South Carolina Future Minds

[redacted]

Questionnaire Questions

1. How do you continually improve your teaching practice when it comes to STEM?
2. How is STEM being implemented at your school?
3. When a student has a difficulty understanding a STEM concept, what steps do you take?
4. How does STEM help high achieving students?
5. How does STEM help low achieving students?
6. How does the use of technology enable students to communicate and collaborate?
7. What types of technology-enhanced projects that approach real-world applications of technology are utilized?
8. How do students develop problem-solving skills through the implementation of STEM?
9. What type of activities with a real-world context do you have the students complete?
10. How do students use the strategies from STEM in other subject areas?
11. How are students able to reason both abstractly and quantitatively through STEM?
12. How are students encouraged to do their best?
13. How do students include others' perspectives when making decisions?
14. How is the engineering design process implemented?
15. How do you take responsibility for all students' learning?
16. What variety of assessments do you use throughout the year to evaluate progress?
17. How do you empower students?
18. How have you seen academic achievements in other areas, using what the students learned in STEM?
19. How do you promote higher-order thinking, analysis, synthesis and evaluation of ideas and information?
20. How do you ensure that your students manage their time wisely?

Interview Questions

1. In your own words, how would you define STEM education?
2. What are some examples of real-world outcomes for students who have an effective science or STEM education?
3. What do you think a classroom that integrates STEM looks like and feels like?
4. What are some ways STEM can be integrated across content areas?
5. In general, what do you think is needed to provide quality STEM education?
6. What are your non-science peers' perceptions on STEM education and why do you think this?
7. What are some examples of collaboration between science and non-science teachers in your school?
8. Why is understanding STEM education important to you?
9. What are some partnerships (e.g. with community, non-profits, universities, businesses, industry, etc.), if any, that your school has formed to help further STEM education?
10. What science teaching and learning practices are expected by teachers to utilize in the classroom?
11. How do you feel you would be able to increase effective STEM education at your school?
12. What are some challenges that you, personally, face on the way to supporting STEM education?
13. What are some challenges that your school faces when supporting STEM education?
14. Many schools have common resources. Please list some key resources you have at your school that support STEM education.
15. What do you feel YOU need to better support STEM education?
16. What differences have you noticed when it comes to student perseverance in terms of STEM education?
17. How has STEM education improved student achievement?
18. How has STEM education been a topic of discussion in your district and school?
19. Describe the students' relationships with, and a sense of ownership over, their learning experiences?
20. How do you challenge the students in their coursework with STEM?

Appendix Q

T-STEM Survey Summary

Construct	Measurement Application
Personal Teaching Efficacy and Beliefs	self-efficacy and confidence related to teaching the specific STEM subject
Teaching Outcome Expectancy Beliefs	degree to which the respondent believes, in general, student-learning in the specific STEM subject can be impacted by actions of teachers
Student Technology Use	how often students use technology in the respondent's classes
STEM Instruction	how often the respondent uses certain STEM instructional practices
21st Century Learning Attitudes	attitudes toward 21st century learning
Teacher Leadership Attitudes	attitudes toward teacher leadership activities
STEM Career Awareness	awareness of STEM careers and where to find resources for further information

Item 5 in the Personal Teaching Efficacy and Beliefs construct, "I wonder if I have the skills necessary to teach [STEM subject]," is negatively worded. All other items are positively worded. From *Teacher Efficacy and Beliefs Toward STEM Survey*, by Friday Institute for Educational Innovation, 2012.

Appendix R

Permission to Use Interview Questions

permission to use survey questions Inbox ×

[redacted]

Marsha Neal [redacted] Sat, Feb 29, 9:04 AM (5 days ago)
to [redacted]

Good afternoon. I am in the process of working on my dissertation through the American College of Education. My dissertation is on the impact of STEM education on middle schools in Southeastern South Carolina - a qualitative phenomenological study.
While researching interview and questionnaire questions to use, I came upon your 2 papers:
CHICAGO-AREA K-8 TEACHER AND ADMINISTRATOR PERCEPTIONS OF STEM EDUCATION By: Ashley Chiu, M.S., C. Aaron Price, Ph.D, Elsie Ovrahim, M.Ed, Museum of Science and Industry
and
ARE WE SO DIFFERENT? A STUDY OF TEACHER AND ADMINISTRATOR PERCEPTIONS OF SCIENCE EDUCATION By: [redacted]. Museum of Science and Industry, Chicago Presented at the National Association of Research in Science Teaching 2016 Annual Conference, April 17, 2016, Baltimore, MD

I am asking permission to use some of the questions that were used in these papers for my research.

Please let me know how to go about getting permission.

Thanks!

--
Marsha Neal, M.Ed., NBCT
6th grade math/science Teacher
[redacted]

[redacted]

[redacted] Mar 4, 2020, 4:07 PM (1 day ago)
to me

Hi, Marsha.

Yes, you can use the questions. Just please cite our papers appropriately. Good luck!

Be well,
--
[redacted]
Director, Research and Evaluation

Museum of Science and Industry, Chicago
5700 S Lake Shore Drive, Chicago, IL 60637
[redacted]

museum of science+industry chicago

Appendix S

T-STEM Survey Reliability

Construct	Number of Items	Cronbach's Alpha				
		Science (n=154)	Technology (n=59)	Engineering (n=9)	Math (n=102)	Elementary (n=228)
Personal Teaching Efficacy and Beliefs	11	.908	N/A	N/A	.943	.905 (Sci) .939 (Math)
Teaching Outcome Expectancy Beliefs	9	.814	N/A	N/A	.849	.854 (Sci) .895 (Math)
Student Technology Use	8	.900	N/A	N/A	.869	.943
STEM Instruction	14	.934	N/A	N/A	.929	.95
21st Century Learning Attitudes	11	.948	.948	.948	.948	.948
Teacher Leadership Attitudes	6	.870	.870	.870	.870	.870
STEM Career Awareness	4	.945	.945	.945	.945	.945

From *Teacher Efficacy and Beliefs Toward STEM Survey*, by Friday Institute for Educational Innovation, 2012.

Appendix T

Museum of Science and Industry Validation of Study

TOTAL SURVEYED (100%)	350 administrators and teachers
Administrators surveyed	175
Teachers surveyed	175
RESPONDENTS (18%)	64 administrators and teachers
Administrators	17 (9%)
Teachers	47 (27%)

From *Chicago-area K-8 teacher and administration perceptions of STEM education*, by Science Leadership Initiative, 2015.