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Use of Technology to Promote Science, Technology, Engineering, and Mathematics Learning in Elementary Classrooms

Theresa Wiggins
Walden University

Walden University

College of Education

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Theresa Wiggins

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Review Committee
Dr. Gladys Arome, Committee Chairperson, Education Faculty
Dr. Heather Pederson, Committee Member, Education Faculty
Dr. Dimitrios Vlachopoulos, University Reviewer, Education Faculty

Chief Academic Officer and Provost
Sue Subocz, Ph.D.

Walden University
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Abstract

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MS, Walden University, 2011

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Dissertation Submitted in Partial Fulfillment

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Abstract

Many students have been exposed to science, technology, engineering, and math (STEM) in most schools. While STEM in public high schools, public middle schools, STEM-specific schools, and charter elementary schools have been researched often, the literature concerning STEM in public elementary school classrooms to promote learning is scarce. The purpose of this study was to explore elementary school teachers' use of technology, such as digital cameras, iPads, and laptops in STEM lessons. Vygotsky's constructivism theory was the conceptual framework used to guide the qualitative research questions in this study, which sought to explore how elementary public school teachers used technology in STEM lessons, how their knowledge of STEM influenced their ability to integrate technology, and how professional development supported teachers' technology integration in STEM lessons. A basic qualitative methodology was used to examine 10 elementary teachers' knowledge of STEM and the integration of technology. Using purposeful sampling, teachers in the middle region of South Carolina who teach STEM lessons were interviewed. Through the use of spreadsheets, the data were analyzed to identify themes. Key results showed that public school elementary teachers integrated technology in STEM lessons in distinct ways to promote learning. There are implications for social change in STEM Careers. Elementary teachers who have effective professional development in technology integration, could promote more elementary students' interest in STEM careers and that would lead to a greater response to STEM careers.

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Learning in Elementary Classrooms

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Dedication

To the entire Wiggins, McCray, and Lee Family! I know this sets the bar high for my family, but if I can do it, so can you!

Acknowledgments

To my maker, thank you for the strength to get through this journey. To my children Davette and David, I know you guys wanted me to be at many family events, but I could not. I can now take time and attend all the events and functions that you all have. I am so glad that I have two exceptional children who have sacrificed spending time with me and supported me in other ways. I am proud to be your mother and accomplished this goal so that you all would be more than proud to call me your mother. To my mother, Catherine, thank you for all the late-night talks and encouragement. You embarked upon this journey with me even though you did not realize it. Thank you, mommy and Deborah McFadden, for going with me to my residencies to eliminate me driving by myself. I feel blessed to have such delightful cheerleaders in my corner. Thank you, Dr. Jenkins, who believed in me when I did not believe in myself, who saw greatness in me when I did not see it myself. Thank you for encouraging me to pursue all of my dreams despite what others thought. I would also like to thank Dr. Arome, my constant encourager, throughout this entire journey. Oh, the times that I had no clarity, you would simplify the process to make it more clear to me. As I have always said, "you are a God sent," and I thank you! Thank you, Dr. Vlachopoulos, for your review and constructive feedback. It is greatly appreciated! Thank you, Dr. Hyder, who worked with my chair to help me complete my dissertation! Thank you, Dr. Pederson who filled in as my methodologist with prompt feedback! Thank you to my entire team at Walden University for all of the support during this journey.

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Chapter 1: Introduction to the Study

Introduction

For the past decades, STEM education has been a top priority for schools worldwide (Holmlund et al., 2018). Researchers found that past presidents have invested plenty of funds and educational initiatives for the implementation of STEM in schools (Handelsman & Smith, 2016). Specifically, President Bush introduced the "American Competitiveness Initiative," which was supposed to bring about advancement in innovation through the teaching of math and science (Preston, 2018). President Obama added to the initiatives by introducing a program to train STEM teachers (Handelsman & Smith, 2016). The Obama initiative, STEM 2026, brought together experts and leaders in the field of science, technology, engineer, and mathematics, to share their expertise for an innovative future of STEM (U.S. Department of Education, 2016). Obama's vision for the United States educators started in the primary grades through to post-secondary (U.S. Department of Education, 2016). That vision required a budget of over 3 billion dollars and was supposed to attract more women and minorities into STEM (Preston, 2018). Finally, the U.S. Department of Education (2017) asserted that President Trump had invested over 200 million dollars in STEM education funding. However, although funding has been provided, elementary educators continue to face challenges implementing STEM in the classrooms (Ravipati, 2017). Estapa and Tank (2017) found that one challenge is elementary teachers' knowledge concerning STEM education. Ring et al. (2017) found that K12 educators' beliefs and knowledge in teaching challenge their approach to teaching STEM lessons. However, Baker and Galanti (2017) found that providing professional development for elementary teachers to implement STEM lessons in their classrooms could minimize the challenges. This study aimed to explore elementary school teachers' integration of technology, such as digital cameras, iPads, and laptops, in STEM lessons. The topic of STEM has been at the forefront of education policy; however, elementary teachers in public schools have recently begun to teach STEM lessons in their classrooms (Estapa & Tank, 2017). While there is an abundance of literature on STEM in public high school, public middle schools, STEM, and charter elementary schools, however, there is a gap in the literature concerning STEM in public elementary school classrooms to promote learning.

This study aimed to impact South Carolina elementary public schools in a positive manner. Through this study, public school elementary teachers in South Carolina may gain a better understanding of utilizing technology such as iPads, laptops, and digital cameras in STEM lessons to promote learning in the classroom. Also, students introduced to STEM at an early age are more apt to continue in STEM, promoting a trickle effect (Malone et al., 2018). This trickle could potentially increase the pool of students entering STEM careers. Malone et al. (2018) found that it could potentially contribute to students entering STEM majors by introducing STEM in primary grades.

Background

There are several publications in which researchers have examined the utilization of technology in STEM classrooms. Parker et al. (2015) conducted a grounded theory study of public school elementary teachers from schools in an urban school district concerning professional development to implement a STEM curriculum. The researchers found that providing teachers with quality technology such as videos, websites, computers, and other technology devices supporting student learning and quality professional development provided teachers with better support for student learning. This research study related to my study because Parker et al. (2015) assessed classroom practices learned through professional development and those practices will contribute to the information indicated in my study. These classroom practices include but are not limited to modeling, reflections, more time, and support from administrators (Parker et al., 2015).

Researchers selected Kindergarten through Grade 12 (K12) teachers and administrators from a state on the East Coast of the United States for a qualitative study to find challenges and obstacles of implementing integrated STEM education (Shernoff et al., 2017). The researchers found several challenges while integrating STEM. Among these challenges were issues such as lack of understanding, resources, professional development, and time (Shernoff et al., 2017). This study was relevant to my research because researchers indicated that there are necessities for teachers to implement STEM, which includes professional development, time, resources, communication, and a change in teachers' attitudes (Shernoff et al., 2017).

El-Deghaidy and Mansour (2015) sought to identify teacher's perceptions of STEM. The researchers found that teachers were justifiably concerned about how well prepared they were to teach STEM. The researchers in this qualitative study used focus groups, teacher-reflections, and interviews to discover the perceptions that science teachers have about STEM. This team of researchers found that teachers were knowledgeable about STEM and realized that it promotes 21st Century skills that are beneficial for students' success (El-Deghaidy & Mansour, 2015). El-Deghaidy and Mansour also found that school culture is a crucial point in implementing STEM. This study was relevant to my research study because El-Deghaidy and Mansour discussed some of the challenges teachers face with facilitating STEM instruction.

Madden et al. (2016) conducted an exploratory study of current and recent undergraduate students from the School of Education at a public college in the northeastern United States. The researchers surveyed education majors to determine their perception of the importance of STEM education in elementary grades. Madden et al. (2016) found that all of the respondents perceived STEM education in elementary grades to be necessary with variations of reasons, including preparing students for the future, promoting higher order thinking skills, and teaching students to be critical thinkers. This study is relevant to my study because elementary school is the setting for my STEM education research. The researchers revealed examples of the responses as to why pre-service and novice teachers perceive STEM education to be important in elementary school.

LaForce et al. (2017) examined the use of problem- and project-based learning in STEM high schools across the United States. The researchers identified seven states with established STEM based on a set of criteria, and they chose schools that were willing and eager to participate in a large research study (LaForce et al., 2017). The researchers found a link between PBL and future STEM careers, and PBL may be one method of enhancing STEM interest in students. This study was relevant because the researchers indicate that students' interest in STEM can increase through PBL, and my study relates to PBL as an inclusion of STEM lessons.

Ring et al. (2017) conducted a case study to understand teachers' conceptions concerning STEM integration. The National Science Foundation (NSF) provided a summer professional development program to promote K–12 STEM integration. Ring et al. (2017) sought to explore teachers' conceptions of STEM. The researchers found that teachers' integrated STEM conceptions shifted during their professional development (Ring et al., 2017, p.454). This study was relevant to my study because it gives information regarding the professional development of STEM and the impact on teachers' conception.

Some research has been done on STEM lessons in elementary classrooms but not with technology as the focus. For example, Baker and Galanti (2017) researched STEM in elementary class with a focus on math. Van Ingen et al. (2018) studied STEM and culturally responsive teaching in elementary schools. Estapa and Tank (2017) investigated STEM with a focus on the engineering design. Technology is another STEM discipline, but there is a gap in research on elementary teachers' integration of technology such as iPads, laptops, and digital cameras in STEM lessons. There is a need for elementary teachers to understand how to integrate technology, such as iPads, laptops, and digital cameras, during STEM lessons.

Problem Statement

The problem is that elementary school teachers are implementing STEM in public school classrooms without integrating technology such as iPads, laptops, and digital cameras. Teachers can connect science, engineering, and mathematics disciplines but leave out the technology discipline (Holmlund et al., 2018). Technology should be integrated into STEM classes being taught in elementary schools. The field of educational technology is broad and covers a variety of technology to include STEM learning. U.S. Department of Education (2017) indicated that educational technology has the power to shift the classroom set up from teacher as program or instructor to a more student-centered environment, which makes learners accountable for their own learning. The U.S. Department of Education (2017) provided insight into teachers' roles utilizing educational technology. According to Stošić (2015), educational technology has three domains: tutor, teaching tool, and learning tool. STEM, which integrates science, technology, engineering, and mathematics, is included in educational technology because it comprises learners utilizing various technology modes in the educational setting in different ways to help solve real-world problems. Educators use STEM to help develop students with 21st Century skills, which consist of various skills such as the 4-Cs, which stands for creativity, communication, collaboration, and critical thinking (Soule & Warrick, 2015).

The "T" in STEM represents various technology tools utilized in the elementary classroom. These tools are used to promote collaborative learning in an integrative learning environment. The change from open book to the teacher's integration of technology tools to promote learning in elementary school classrooms is a subject of interest (Pine-Thomas, 2017). Technology is continually changing and being replaced with something new (Ragin, 2016). Teachers realize that staying abreast of emerging technology will ensure that they can integrate technology into classrooms. According to Ragin (2016), textbooks are no longer used to enhance the process of knowledge acquisition; it is technology. There is an insignificant amount of research that has been done on the utilization of technology in elementary classrooms. The amount of research on public school elementary school teachers' integration of digital technology such as iPads, laptops, and digital cameras in STEM classes is even smaller. STEM is a curriculum that combines the disciplines of science, technology, engineering, and mathematics. The gap in the research is STEM lessons that are taught by elementary school teachers and the integration of technology such as iPads, laptops, and digital cameras in these lessons. This study provides insight into public school elementary school STEM teachers concerning integrating technology in STEM lessons.

Purpose of the Study

The purpose of this basic qualitative study was to explore how elementary school teachers integrated digital technology such as iPads, Laptops, and Digital Cameras when teaching STEM lessons in the classroom. Today technology is integrated into the classrooms throughout the world (Cambridge Assessment International Education, 2018). The phenomenon of interest is to investigate how elementary teachers integrate technology in STEM lessons.

Research Questions

Research Question 1 (RQ1): How do elementary school teachers utilize and integrate technology in STEM classes?

Subquestion 1a (SQ1a): How does the knowledge of STEM influence elementary school teachers' ability to integrate technology in STEM classes?

Subquestion 1b (SQ1b): How does professional development regarding technology integration provide support for STEM elementary school teachers?

Conceptual Framework for the Study

This study was framed through the lenses of social constructivist theory concerning STEM. Education, as well as technology, has changed significantly over time. Society has placed STEM education at the forefront of teaching with the notion that problem-based learning will bring about a positive societal change (Ossola, 2014). STEM uses the integration of subject areas to solve real-world problems (Jolly, 2016). The social constructivist theory supports the framework of STEM due to student interaction's relevance with integrating different subject areas. The social constructivist theory supports complex, multifaceted, and divergent learning (Lowyck, 2014). Social constructivist theory dwells on the ideology that social interaction promotes learning (Lowyck, 2014). One of the areas of focus for STEM is problem-based learning, which is supported by social constructivism. Social constructivism promotes group discussions, which, according to van Merriënboer and de Bruin (2014), "increases student motivation and builds a deeper understanding of what students are learning" (p.27).

Jean Piaget (1896-1980) was the first theorist to accentuate that children construct an understanding of the world (Lowyck, 2014). He believed that children's development precedes their learning (McLeod, 2018). However, Vygotsky (1896-1934) highlighted social interaction's role during children's development (McLeod, 2018). The social constructivist theory follows Piaget's theory but added that social interactions and social relationships help children understand the world (Lowyck, 2014). Vygotsky expressed that learning should be matched to children's development level, which was divided into two levels (Cole et al., 1978). The first level is the actual development level, which is the established mental function based on completing certain cycles of development (Cole et al., 1978). The other level is the zone of proximal development, which "is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers" (Cole et al., 1978. p.86). The key research question and subquestions all focus on STEM. Social constructivism is used as the framework because it correlates with this study. Vygotsky's social constructivist approach supports STEM in social interactions for problem solving and critical thinking as the lessons' foundation. Social constructivism theory implies that learning occurs when individuals are engaged in social activities such as interaction and collaboration

(Amineh & Asl, 2015). Vygotsky's philosophy of social constructivist relates to this research study because it indicates the learning process used in teaching and learning STEM lessons. The key research question in this study was geared toward STEM classes, which focus on problem-based learning. Social constructivism is the foundation of problem-based learning due to the strategies used, such as critical thinking, teamwork, self-directed learning, and problem-solving (Kurz et al., 2015).

Nature of the Study

This study is an exploratory basic qualitative study. According to Ravitch and Carl (2016), qualitative research is a methodological kind of inquiry that explores or identifies and describes people's actions and beliefs about what they do in their everyday lives. This qualitative study is exploratory. "Qualitative research requires an extensive and in-depth description of a social issue" (Yin, 2014, p.4). The National Academy of Engineering (NAE) and National Research Council (NRC) found that the discussion concerning STEM is a social phenomenon in the educational policy arena and would require an extensive and in-depth description for stakeholders (NRC, 2014). The explanation for other research designs, such as case study, phenomenology, and narrative, was considered but not chosen can be found in Chapter 3.

The data collection came from elementary school teachers who teach STEM classes in the middle region of South Carolina. Participants are elementary teachers from the southern part of the United States. These elementary school teachers are teachers of Grades 3 through 6. The data collection method was virtual interviews via Skype and email correspondence from elementary school teachers who teach STEM. The participants consisted of 10 elementary school teachers in the southeastern United States who teach STEM.

Definitions

These terms were used throughout this research and are considered useful to understand the context of the study.

21st-century skills: a list of work habits, skills, knowledge, and character traits deemed to be important for success in the world today. These skills include but are not limited to the 4-Cs-creativity, communication, collaboration, and critical thinking (Soule & Warrick, 2015).

Educational Technology: Also considered instructional technology, it is a cognitive tool that could be used by learners to make sense of the world, access information, organize and show what has been learned (Lowyck, 2014).

Professional development: A variety of specialized training to enhance what teachers have already been doing or to help them improve in knowledge, competence, skill, and effectiveness of their teaching skills (Chiyaka et al., 2017).

Project- and Problem-Based Learning (PBL): teachers present students with tasks to complete a project, or teachers provide students with problems they solve using 21^{st}-century skills. Students apply school knowledge to what they know about the world to complete tasks or solve problems (LaForce et al., 2017).

Science, Technology, Engineering, and Mathematics (STEM) lesson: These lessons include the four disciplines of science, technology, engineering, and mathematics, which are incorporated together to promote knowledge and 21st Century skills (White, 2014).

According to Jolly (2016), STEM lessons have features that make them great. The lessons focus on real-world problems, embarking upon the engineering design as the guide, providing students with a hands-on inquiry, collaboration, making sure the math and science are rigorous, providing questions with multiple right answers, and acknowledging that sometimes failing is learning.

Assumptions

This study was based on several assumptions. The first assumption was that I had no connection with the potential participants before this research. This assumption was important because it was my bias that could impact this study's credibility and reliability. The next assumption was that all elementary teachers teach STEM lessons, so my recruitment method eliminated those elementary teachers who did not teach STEM. This assumption was important to the recruitment process to choose participants with the same qualifications to keep the study's reliability. Another assumption was that the participants were elementary teachers who utilized technology as defined in this study in STEM lessons. It was imperative that the technology integrated in this study were technological devices such as iPads, laptops, and digital cameras, to impact its validity. It was also the assumption that the STEM lessons were real-world, problem based, and required collaboration (McLeod, 2018). The last assumption was that the participants in this study would respond honestly during the recruitment and face-to-face interviews. These assumptions had the capability of impacting the validity of this study.

Scope and Delimitations

This basic qualitative study's scope was to gather in-depth information from elementary school teachers who teach STEM lessons with the integration of technology. Several restrictions limited the scope of this study. Since elementary teachers usually teach core subjects such as math, science, social studies, and English/Language Arts, teaching STEM at the elementary level is somewhat new to elementary schools in the South (Will, 2018). Elementary teachers who teach STEM without the integration of technology, as defined in this paper, were excluded.

This study was limited to the participation of elementary school teachers. Third-grade through sixth-grade elementary school teachers who teach STEM lessons in the South were the chosen participants. Those excluded from this study included elementary school students in Grades 3-6, parents of these elementary school students, and elementary school administrators. Kindergarten-Grade 2 teachers and elementary school teachers who teach lessons other than STEM were also excluded from this study.

This study focused on exploring the integration of technology by elementary school teachers in a STEM class. Science STEM is a problem-solving process through science, technology, engineer, and mathematics; social constructivism is the conceptual framework. Technology Acceptance Theory (TAT) was considered; however, this theory deals with teacher acceptance of the technology. Since this study is exploring the use of technology, TAT did not apply. Piaget's theory of cognitive development was considered, but it proposed that there are development stages. This study's focus is comprised of collaboration, which is more aligned to Vygotsky's social interaction. Another consideration for the framework of this study was Technological Pedagogical Content Knowledge (TPACK). After researching this framework, it was determined that it did not apply to the study. This study focused on utilizing technology in STEM lessons, which is considered devices, and with TPACK, technology could be as simple as a spreadsheet (Koehler et al., 2014).

The transferability of the findings from this study may enlighten future research on STEM in early grades. These finding would inform future studies on the utilization of technology in STEM lessons. This study would explain how elementary teachers teach STEM lessons with technology in the South but may extend to other areas in the United States. This study would also provide insight into professional development's necessity to support educators who teach STEM lessons.

Limitations

This basic qualitative study provided limitations for this type of study which are further clarified in Chapter 3. One limitation was the small number of participants in the study. The targeted population was public school elementary teachers, so this study's findings are not representative of a larger population of teachers. All the participants were from the middle region of South Carolina, so there is a limitation to the findings' transferability. As the sole researcher of this study, another limitation was the 10-week time frame devoted to collecting data for this study. This time constraint will be addressed in Chapter 3, where I discuss the triangulation of the data.

Not all teachers teach the same (McLeod, 2018). During the literature review, a gap was revealed concerning the integration of technology in STEM lessons in public elementary schools. Teachers have different definitions of what is included in educational technology. (Kurt, 2016). Elementary teachers who teach STEM lessons may have had challenges integrating technology due to not being knowledgeable about the devices.

Along with limitations were biases that would affect the results. One bias that could have influenced the outcome is the connection that I share through employment at an elementary school in the South and my views on integration of STEM curriculum. Merriam and Tisdell (2015) warned the researcher about eliminating data based on personal opinions and beliefs. Another bias was the time that I, as the sole researcher, had to devote to the collection of data. I provided detailed strategies to improve the trustworthiness of this research by minimizing researcher bias that is addressed further in Chapter 3.

Significance

The results of this study have the potential to help public school elementary educators understand ways to utilize technology in STEM lessons. This study's findings will also potentially draw attention to the importance of integrating technology to teach

STEM lessons in public elementary schools. This study can promote social change in public elementary schools with the way teachers integrate technology in STEM lessons. This study could help elementary teachers who teach STEM lessons to realize that STEM is an intertwining of the four disciplines, including technology (Madden et al., 2016). It could support elementary teachers in the challenges they face with the utilization of technology. This study's potential outcome is that public school elementary teachers will become more knowledgeable about technology and successfully integrate it during STEM lessons.

This study has the potential to promote a positive social change in using educational technology in STEM lessons through national STEM professional development. Elementary school administrators could see the need for effective professional development through this study. The findings may also cause a shift in administrators' focus to provide adequate professional development for elementary teachers in integrating technology to teach STEM lessons. Providing elementary teachers with effective professional development could equip them with knowledge of how to use technology in STEM lessons and of barriers to this instruction that could be eliminated. This study has the potential to provide assurance for elementary teachers from all over the world to become more knowledgeable about technology integration in STEM lessons. This study could also result in the creation of a STEM program that would provide elementary teachers with guidance in integrating technology such as iPads, laptops, and digital cameras.

Summary

In this chapter, I have introduced an exploratory study of STEM elementary school teachers' integration of technology in STEM lessons. Elementary school educators should be able to integrate technology in STEM to promote learning in elementary schools. The purpose of this basic qualitative study was to explore how elementary school teachers integrated technology when teaching STEM lessons in the classroom. This study was significant to the appropriate increase in the utilization of educational technology in elementary classrooms. Chapter 2 will provide information on the literature search strategy and a detailed review of the literature related to technology integration in STEM lessons.

Chapter 2: Literature Review

Introduction

Public school educators have dealt with changes in instruction for decades. Strimel and Grubbs (2016) explained that changes in education were inevitable due to the ever-evolving changes that take place in the world. The most recent change in elementary schools is STEM lessons to prepare students for the future technological-focused world. According to Parker et al. (2015), there was a shortage of STEM-skilled workers, and the government increased funding for STEM education. STEM lessons in elementary schools were being used to cover multiple standards in science and mathematics (Winn et al., 2016). STEM lessons provided students with the 21st-century skills that were deemed necessary to become college and career ready. Some of these skills consisted of critical thinking and problem solving, collaboration, communication, creativity, and effective technology use. The problem was what educators consider technology in STEM lessons and how it helped promote learning in elementary schools (Jolly, 2016). Teachers used technology in their classrooms in different ways. Some used technology to play video clips and to show lessons on the screen (Shin, 2014). Other teachers used technology to integrate multimedia such as PowerPoint, Vimeo, YouTube, Camtasia, Animoto, Prezi, and Xtranormal (Martin & Carr, 2015).

Much research has been done on integrating technology in the classrooms, but not much on integrating technological devices in STEM lessons. The International Society for Technology in Education (ISTE) provides educators' standards for teachers' seven roles: learner, leader, citizen, collaborator, designer, facilitator, and analyst (ISTE, 2017). Each of these roles provides standards to be used as a roadmap for implementing the integration of technology in the classroom (ISTE, 2017). The purpose of this qualitative case study was to explore how elementary school educators integrated technological devices in STEM lessons to promote learning in elementary schools.

The major sections in Chapter 2 include an analysis of the socioconstructivist framework, which supports STEM due to the relevance of problem-based learning, student interaction, and social interaction to promote learning. I investigated the components of STEM science, technology, engineer, and mathematics. Last, I included an exploration of technological devices and their integration in STEM lessons in an elementary classroom to promote student learning. These technological devices included but were not limited to mobile devices, networking infrastructure, interactive front-of-class tools, and 3D printers (Edtech Staff, 2020).

Literature Search Strategy

I used Walden University library databases such as Academic Search Complete, Dissertations & Theses, Education Research Complete, ERIC, and ProQuest Computing. I also used search engines outside of Walden, such as Google Scholar, Research Gate, and DOAJ (Directory of Open Access Journals). At first, I explored one key term, STEM, which resulted in over 400,000 articles, so I changed the range of dates. When I changed the range of dates to search for 5 years beginning with 2018, the number of articles decreased to over 100,000.

I could see that the 100,000 articles included STEM referring to cells, so I used several combinations of search terms to get a better range of relevancy. I used the search terms *STEM* and *elementary classrooms*, and that search produced only five articles. I also tried the keywords *STEM* and *science, technology, engineer,* and *mathematics,* which produced eight articles. I then tried the key terms like *STEM* and *technology*, which provided me with over 300 articles. The process took a while to get results based on the combination of words because a lot of the articles from the search results had no relevance to my dissertation topic. I also searched using keywords such as *technology use* and *elementary teachers*, which provided over 500 articles. After applying filters such as the year, full text, and peer-reviewed scholarly journals, the result were reduced to 17 articles. The search for the terms *technology use* and *elementary classrooms* resulted in just one article, so I contacted the Walden Library. Walden University Librarians assisted in my search so that I could reach a point of saturation. After the librarian's assistance, I was able to find more articles with a focus on STEM as it relates to technology, professional development, and student learning.

Conceptual Framework

The conceptual framework for this research paper was based on the socioconstructivist theory. The constructivist theory explains how people know what they know (Learning Theory - Constructivist Approach, 2018). Constructivism is traced back to Piaget's (1896-1980) developmental stages of learning and Vygotsky's (1896-1934) zone of proximal development. These two philosophical figures shared the philosophy of how learning is constructed. However, they differed in the type of construction. Caruso (2016) indicated that both philosophers believed that children must be actively engaged in their learning. Both Piaget and Vygotsky believed that cognitive development declined with age, so as children grew, their cognitive development decreased. However, they did not agree upon the language and thought of cognitive development.

Piaget's constructivist philosophy is cognitive, which implies that the learner uses "schemes, assimilation, accommodation, and equilibrium to create new learning" (Ozer, 2004). Piaget explored the psychological development of learning in children, where he considered four sequential stages that children will undergo based on maturation and experience. Before the age of two, children experience what Piaget calls the Sensory-motor Stage. The second stage is the Preoperational Stage, which includes children ages 2-7. Concrete Operational Stage is the third stage, which includes children ages 7-11. The final stage is Formal Operational, which includes children ages 11 and older (Ozer, 2004).

Vygotsky's philosophy of constructivist is social, which indicates that social interaction provides learners the ability to comprehend concepts and schemes they would not otherwise know (Ozer, 2004). According to Caruso (2016), "Six major assumptions guide Vygotsky's theory: (a) children develop through informal and formal conversations with adults; (b) the first few years of life are critical for development, as this is where thought and language become increasingly independent; (c) complex mental activities begin as basic social activities; (d) children can perform more difficult tasks with the help of a more advanced individual; (e) tasks that are challenging promote cognitive development growth; and (f) play is important and allows children to stretch themselves cognitively" (p.3).

I chose Vygotsky's socioconstructivist approach because STEM uses social interactions for problem-solving and critical thinking as the lessons' foundation. Vygotsky's approach acknowledges the assumption that children learn through social interaction with guidance and collaboration. Lowyck (2014) indicated that social interaction promotes learning and the theory of socioconstructivist supports divergent learning. Socioconstructivism theory implies that learning occurs when individuals are engaged in social activities such as interaction and collaboration (Amineh & Asl, 2015). According to Lynch (2016), "Social constructivism teaches that all knowledge develops as a result of social interaction and language use. Therefore, there is a shared, rather than an individual, experience". Vygotsky's philosophy of socioconstructivist relates to this research study because it indicates the learning process used in teaching and learning STEM lessons.

Literature Review Related to Key Variables and Concepts

Technology has a role in every STEM lesson. According to Jolly (2016), technology in STEM lessons are no longer digital; it is described as any product made by humans to meet a want or need. However, when referring to education, technology is considered a cognitive tool that could transform learning and could be used by learners to make sense of the world, access information, organize and show what has been learned (U.S. Department of Education, 2017). The utilization of technology in the classroom has increased drastically since the 21st century (Chauhan, 2017). From sitting at desktop computers to moving around the classroom with iPads, learning in schools has changed significantly (Domingo & Garganté, 2016). For the sake of this research study, technology was considered a cognitive tool, such as a mobile device. Since technology is ever-evolving, teachers have the opportunity to provide students with 21st-century skills such as critical thinking and problem solving, collaboration, communication, and creativity (Domingo & Garganté, 2016). Promoting exposure to these elementary classrooms' skills promotes inquiry-based learning, sustained attention, and self-direction (Tran, 2018). These 21st skills integrated into instruction leads the way for STEM lessons that engage and excite students in the classroom (Beers, 2013; Boss, 2019)

STEM (Science, Technology, Engineer, Mathematics)

STEM is an acronym used to describe the study of science, technology, engineer, and mathematics. Bell (2016) stated that globally, STEM had become the new initiative in schools, but there is no global definition. However, Tsupros, et al. (2009), Gerlach (2012), Hallinen (2017) all agreed on the best definition of STEM as "an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy" (p.3).

STEM is described by the United States government as subjects for students to obtain skills they need to solve problems, gather and evaluate evidence, and make sense of information (United States Department of Education [U.S. DOE], n.d.). The STEM education movement in the United States began in the early 2000s. It was discovered that U.S. students were not as successful in STEM disciplines as the students in other countries (Hallinen, 2017). In 2015, while in office, President Obama articulated the need for STEM and expressed that there are not enough students with access to an excellent STEM program or class (U.S. DOE, n.d.). STEM provides a platform for students to be engaged in problem-solving, critical thinking, tool use, curriculum integration, and an array of other skills due to the potential for exploring complex situations and ill-structured problems and building prototypes (Sias et al., 2016). Some schools offer STEM as a summer program or as an afterschool program; however, STEM should be integrated into the classroom during the regular school day (Estapa & Tank, 2017).

According to researchers, there are still concerns about STEM and its implementation in schools to prepare for future STEM professionals (Smith et al., 2018). It has been suggested that K12 teachers develop a deeper understanding of STEM and explores what STEM lessons should look like in the classroom (Ring et al., 2017). STEM was described by Jolly (2016) as a method of incorporating different subjects into the curriculum. Krajcik and Delen (2017) described STEM as a focus on solving problems by integrating the four disciplines. National Science Foundation (NSF) has played a major role in the call for STEM in education to prepare students for STEM careers (Holmlund et al., 2018). Isabelle (2017) found that the Next Generation Science Standards (NGSS) provided goals for combined subject areas necessary for students to succeed in STEM beginning at the elementary level. The integration of educational technologies was necessary to make STEM effective (Wu & Anderson, 2015).

Researchers have found that STEM was being taught to students in elementary schools but not as a priority and not for all students in elementary school (Asunda & Walker, 2018). Researchers provided several beliefs about students who were exposed to STEM. One belief was that students who were exposed to STEM are well rounded and equipped for future success (U.S. Department of Education, 2016). Another belief was that exposure to STEM in preschool had a serious effect on students' developmental and process skills (Aldemir & Kermani, 2017). Researchers discovered that the 21st Century skills such as collaboration, communication, and perseverance were heightened in students with STEM (Holmlund et al., 2018).

Asunda and Walker (2018) acknowledged that STEM was not the same at all schools due to the differences in school populations, challenges, and needs. Bell (2016) discovered that when teachers' knowledge and understanding of STEM was lacking, students' learning was limited. According to Bell (2016), having well-qualified teachers was an integral part of STEM education so that the learning was not limited.

Professional Development for Teachers Who Teach STEM

The many changes to public elementary schools have created complexities and challenges for teachers. New standards require professional development, new strategies to teaching requires professional development, and new educational initiatives such as STEM requires professional development (Gardner et al., 2019). Hallinen (2017) found that teachers were not prepared to guide students into STEM career fields because they did not have in-depth knowledge of STEM careers. It was also found that teachers' beliefs and knowledge affected the quality and integration in STEM lessons (Ring et al., 2017). Reinking and Martin (2018) asserted that teachers were interested in STEM because it is the "cross-curricular infusion of science, technology, engineering, and math" but would need to learn strategies (p.425).

Krajcik and Delen (2017) discovered that teachers would need to shift their thinking and teaching practices to ensure students met STEM goals. El-Deghaidy et al. (2017) believed that teachers did not have the necessary confidence to teach STEM. Other researchers have found that some educators' challenges included the lack of STEM curriculum materials and the professional development needed to know how to use them (Sinatra et al., 2017). Researchers also discovered technical, political, and cultural barriers to effective teaching (Parker et al., 2015). Asunda and Walker (2018) found that it was necessary to address the barriers that teachers face to promote the success of STEM lessons.

Many aspects of educational reform shifted the focus to the teacher and their ability to provide improvement of testing data (McComb & Eather, 2017). Professional development became the center of educational transformation. Providing teachers with adequate support and training has helped in conquering the challenges. McComb and Eather (2017) disclosed that through teachers receiving professional development, they could participate in many learning sessions of varied instructional approaches that they can take back and utilize in their classrooms. Providing teachers with an opportunity to practice and reflect is a form of professional development that improves teachers' competency in their content area (Smith et al., 2018).

Professional development for teachers is usually a training method to enhance what teachers have already been doing or improve certain areas of their teaching skills (Chiyaka et al., 2017). Researchers found professional development needs to be changed to Teacher Professional Development (TPD) and should be continuous with addressing "teacher needs, school context and the problems and challenges encountered in the teaching practice" (Looi et al., 2017. p.106). Parker et al. (2015) found that effective professional development focused on critical areas such as coherence, content focus, active learning, collective participation, and duration (p.295). Through research, McComb and Eather (2017) found that effective professional development was reflective, collaborative, and relative to their distinct discipline. Professional development should be reflective in the arena of their beliefs about values and credence related to teaching and learning, which may require teachers to change their beliefs and attitudes to improve their teaching outcomes (McComb & Eather, 2017).

Darling-Hammond et al. (2017) found that professional development should require teachers to reflect on their beliefs and attitudes. Teachers should also reflect on the entire teaching profession, which includes teaching methods, activities, knowledge of content, student engagement, and student knowledge development. Professional development should be collaborative so that teachers share ideas and work together to provide constructive and critical feedback to each other to improve teaching practices (McComb & Eather, 2017). Darling-Hammond et al. (2017) described collaboration as collective participation, which is an important aspect of professional development because it provided educators an opportunity to discuss concepts, skills, problems, and teaching ideas. Professional development should be relative to the teacher's distinct discipline so that the focus is on how students learn and develop in that discipline (McComb & Eather, 2017). Darling-Hammond et al. (2017) found that active learning during professional development gives teachers a chance to improve their knowledge of the content in their discipline and explain how that knowledge is constructed.

Professional development is an important part of teacher development, but there is no one size fit all when it comes to STEM. Researchers found that teachers who teach STEM need professional development that provides several things. These things consist of "opportunities for teachers to voice what they needed to learn, work collaboratively to build a strong sense of community, explore the state standards to understand what is important for the students to learn, and to model what and how they should proceed with STEM lessons" (Leonard, & Piscitelli, 2017). Other researchers found that effective professional development consisted of several characteristics such as being content-focused, provided active learning, supported collaboration, provided modeling of effective practice and support, as well as proposed opportunities for feedback (Darling-Hammond et al., 2017). Gardner et al. (2019) ascertain that for professional development to be effective, the focus should be on the "teachers' understanding of content and teaching methods through active learning. The researchers stated that professional development modeled e□ective practices coherent with previous and future teaching goals of the learning agency, and it is sustained and continued with coaching or expert support" (p. 2).

Technology

Educational Technology

The world is ever-changing regarding technology, but many schools are not changing to prepare students for the 21st century (Boss, 2019). The focus in the United States has been to increase technology access in schools to spark students' interest in innovation as well as broadening global competition (McKnight et al., 2016). Educational technology, also termed instructional technology, when used appropriately, could yield positive results for student engagement in "authentic learning opportunities, and application of skills and knowledge that reinforced deep learning" (Sias et al., 2016. p.228).

Researchers found that school administrators have banned some technological devices such as cell phones in the past. However, today they allow students to use these devices for communication and collaboration in the classroom (Beatty et al., 2017)). Mobile technology has been found to be useful in the classrooms to explore access to a variety of applications like coding (Estapa et al.,, 2017). Voogt and Knezek (2018) indicated that technology is an important approach to many educational needs. There is a need for leaders in the technology discipline in order to get the best technology integration in schools.

The 21st century has provided a wealth of technological tools and devices for teachers to integrate into lessons (Martin & Carr, 2015). Alismail and McGuire (2015) found that there were multiple technological devices that allowed students to work collaboratively. Technology in the classroom provides unlimited access to learning besides what is taught within the building (U.S. Department of Education, 2017).

McKnight et al. (2016) found that technology takes on at least five different roles in the classroom to help impact learning. One role of technology is to improve access to information. Technology provides a plethora of information and materials other than textbooks (McKnight et al., 2016). Another role is that technology improves communication. Communication should be between all educational stakeholders, including teachers, parents, students, administrators, and school boards (McKnight et al., 2016). Technology restructures time for teachers so that they can provide more individualized instruction. McKnight et al. (2016) stated that technology extends learning so that students are physically in the classroom but can explore any place on Earth and beyond using technology. The last of the roles is a shift in the classroom, where students construct their own knowledge, and teachers are facilitators (McKnight et al., 2016).

Researchers found that 21st-century learners used digital learning to become college and career ready, and educators should embrace technology (U.S. Department of Education, 2017). The utilization of technological tools was considered the best method to improve student learning through problem solving and innovation (Alismail & McGuire, 2015). McKnight et al. (2016) found that technology access also improved students' critical thinking and problem-solving skills when using it to find information and research. Kormos (2018) implied that the integration of technology in the classroom provided teachers an opportunity to promote learning 21st-century skills like communication, critical thinking, collaboration, and communication.

The use of technology in STEM

With the government's investments to equip schools providing schools the ability to become 1:1 with technology, some teachers had challenges in integrating the technology. Alismail and McGuire (2015) discovered that it is important for students to utilize technology and creativity to support learning. Teachers could make learning relevant to students through the effective integration of technology (Daggett, 2014). Scalise (2016) discovered that too much technology use or too little technology use is due to the lack of technology planning.

The utilization of technology allowed students to research and obtain information to expand their knowledge (Alismail & McGuire, 2015). Some teachers do not receive guidance on integrating different technology, so they have different thoughts on how technology should be integrated into STEM lessons (Constantine et al., 2017). Scalise (2016) found that without a curriculum for teachers to teach technology skills, they develop their own.

The 21st Century has provided a wealth of technological tools and devices for teachers to integrate into lessons (Martin & Carr, 2015). Researchers found that teachers have different beliefs about the purpose of technology in STEM lessons (Constantine et al., 2017). When using technology in STEM lessons, some teachers believed technology was a tool that advanced learning. Some teachers believed that technology was just as important as science, engineering, and math and should be rendered just as much, and some teachers believed that technology was a tool (Constantine et al., 2017).

Alismail and McGuire (2015) found that there were multiple technological devices that allowed students to work collaboratively. Estapa et al. (2017) reported that there was a wide variety of computer applications that were useful in the classroom. With technology, multimedia tools such as Portfolios, WebQuests, Quizzes, Wiki, Google site, Digital Storytelling, and ePortfolios can be used to provide help with learning 21st-century skills such as problem solving, critical thinking, and collaborative learning (Alismail & McGuire, 2015). Technology applications like Scratch, Alice, Kodu, and Greenfoot focused on providing students with experience in design and creativity, and computational thinking (Estapa et al., 2017).

Elementary Education

For the past decades, the elementary classroom model has been teacher-centered, where students were required to memorize information (Alismail & McGuire, 2015). The focus in elementary education is primarily English Language Arts (ELA) and math, but if subjects could be combined, the content would then cover many more domains of subject matter (Peterson, 2017). Teachers have no problems teaching one or two content subjects interchangeably, but when it comes to four disciplines, there is a struggle (El-Deghaidy et al., 2017). Toma and Greca (2018) found that students are at the age where STEM interest is either peaked or declined in elementary grades.

Tran (2018) suggested beginning exposing students to STEM in elementary classrooms because this will begin the skill-building process. Some researchers acknowledged that STEM education is important at the elementary level; however, math and science are often allotted more time to teach than any other subject area (Madden et al., 2016). STEM teachers are important at the elementary level, but it has been found that administrators have been reluctant to hire STEM teachers because they struggled to find elementary teachers who were experts and passionate with math and science content as well as proficient in engineering and technology and who were not afraid to try new activities ad experiments (Shernoff et al., 2017). Researchers have found that science and math are consistently taught in elementary education; however, engineering focuses on higher education and technology in vocational education (Holmlund et al., 2018).

The use of STEM lessons in the classroom could change student behaviors and improve academics because of STEM's hands-on and engaging nature (Capraro et al., 2016). Alismail and McGuire (2015) found that today schools across the states have changed from teacher-centered to more student-centered through the adoption of Common Core State Standards (CCSS). The CCSS provides students an opportunity to master 21st Century skills such as critical thinking, communication, collaboration, and creativity (Alismail & McGuire, 2015). Students attain these 21st Century skills through the engagement of STEM lessons (Peterson, 2017).

Strimel and Grubbs (2016) stated that the Next Generation Science Standards (NGSS) was one of the United States educational initiatives to promote STEM. NGSS provides goals necessary to achieve student success in STEM (Isabelle, 2017; Madden et al., 2016). The NGSS goals include engineer design standards, such as performance expectations. These performance expectations focus on students asking questions, making observations, and gathering information. The science and engineering practices are disciplines of students asking questions based on observations and disciplinary core ideas like understanding the problem (Estapa et al., 2017). Winn et al. (2016) discovered that both the CCSS and the NGSS provide science and math goals, sometimes using similar vocabulary terms with different meanings. McKinney et al. (2017) found that NGSS and CCSS identified integral parts of STEM learning deemed necessary for STEM lessons such as critical, analytical, and logical thinking. Researchers believed that combining CCSS and NGSS provides a blueprint for STEM in elementary schools; however, it was found that the differences of the terminology used in the NGSS and CCSS make it unlikely (Winn et al., 2016). Research showed positive results for STEM lessons taught in elementary classrooms (van Ingen, Davis et al., 2018).

The world is in high demand for workers with STEM skills (Parker et al., 2015). When ranking countries that produce STEM graduates, the United States ranked 27 (Parker et al., 2015). To produce STEM graduates, teachers should use STEM lessons. Toma and Greca (2018) found that teachers were reluctant to use STEM in elementary classes. Researchers found that STEM could enhance students' learning when teachers found out more about their students and connected their lives to their learning (van Ingen et al., 2018). Using Problem Based Learning (PBL) is one STEM focus that could enhance students' interest in STEM (LaForce et al., 2017).

Jolly (2016) provided six characteristics for a STEM lesson to be considered great. The six characteristics include but are not limited to great STEM lessons that focused on several principles. One of which was lessons that provided real-world problems. Another was lessons that are guided by the engineering design process. Lessons that engaged students with hands-on inquiry was another characteristic. The fourth characteristic was lessons that incorporated teamwork. Another is lessons that include the current math and science content. The last of the six characteristics were lessons that provided multiple answers to prevent wrong answers (Jolly, 2016. Pp. 2-3).

Estapa and Tank (2017) asserted that there is no one way to teach STEM, but there should be commonalities for teachers to use towards unified goals. Students should be provided with an opportunity to collaborate with professionals within the STEM career fields to learn what career choices are available through STEM (van Ingen et al., 2018).

Teaching STEM is promoted through learning performances with clear and specific learning goals (Krajcik & Delen, 2017). Wu and Anderson (2015) discovered that educators considered STEM assessments an important part of student success. Isabelle (2017) found that for students to be successful in STEM, they needed to begin to think and act like scientists beginning in elementary school. STEM not only supports academics but also supports certain aspects of students' creativity and thinking ability (Estapa et al., 2017).

Peterson (2017) asserted that STEM is a student-centered learning approach that presents students with a real-life problem, and they used the engineering design to find a realistic solution. Students learned different problem-solving processes through STEM lessons, such as computational thinking (Estapa et al., 2017). According to Estapa et al. (2017), students need to be exposed to this skill early in life.

Summary

This literature review has concluded that technology is an important aspect of STEM lessons. It has been discovered that teachers should be trained to teach STEM. It was also brought to the forefront in the literature that teachers need professional development to be able to be successful in the integration of technology in STEM lessons. Researchers presented several characteristics of STEM lessons. Students can learn various 21^{st}-century skills through STEM lessons, including critical thinking, communication, collaboration, design, and creativity. Exposure to certain technological devices and software can promote computational and critical thinking in students. In Chapter 3, I provide detail about the chosen methodology explaining the chosen design and rationale. I also explain my role, participant selection, the collection of data, and lastly, the issues of trustworthiness.

Chapter 3: Research Method

Introduction

The purpose of this basic qualitative study was to explore elementary teachers' integration of technology in STEM lessons. There was a wealth of literature concerning the utilization of technology in elementary classes. There was also an abundance of research concerning STEM in elementary schools. However, there was limited research on integrating technology such as iPads, Laptops, and Digital Cameras in STEM lessons in elementary schools.

In this chapter, I discuss the methodology used in the research through five different sections. First, I identified the research design and rationale. This section includes the research questions and the research approach. Next, I discuss my role as the researcher and how my position was defined by collecting and analyzing data and any biases and issues. The third section is the methodology section. This section of the chapter provides a profusion of information about the logic behind the participant selection and data collection, instruments, and analysis. The next section addresses the issues of trustworthiness, which explores procedures and strategies for credibility, transferability, dependability, confirmability, and ethical procedures. The last section of the chapter concludes with a summary.

Research Design and Rationale

The research questions that guided this study were based on the notion that STEM is a priority in schools (U.S. Department of Education, 2016). This study explored how elementary teachers integrated technology in STEM lessons.

RQ1: How do elementary school teachers utilize and integrate technology in STEM classes?

SQ1a: How does the knowledge of STEM influence elementary school teachers' ability to integrate technology in STEM classes?

SQ1b: How does professional development regarding technology integration provide support for STEM elementary school teachers?

These questions aligned with this qualitative research study in several ways. The social constructivism framework was one way that the questions explored in this study aligns. The main question sought to explore elementary teachers' technology integration. The integration and utilization of technology are necessary for teachers, but it is vital for teaching STEM classes (EdTech Staff, 2020). Student interaction is one of the processes of social constructivism, and interaction is provided in STEM through various technologies such as desktops and mobile devices.

The subquestions sought to explore elementary teachers' knowledge of STEM. Teacher's knowledge of STEM is essential for them to be able to integrate technology. Social Constructivism is the foundation of problem-based learning, and STEM is problem-based learning. Social constructivism allows for learners to construct their own learning through hands-on activities (Posts, 2016).

Table 1

Alignment to Framework

Research Questions	Question Number	Alignment to Framework
How do elementary school teachers utilize and integrate technology in STEM classes?	RQ#1	Social constructivism allows for interaction among students.
How does the knowledge of STEM influence elementary school teachers' ability to integrate technology in STEM classes?	SQ#1	Social constructivism is the foundation of problem-based learning (Kurz et al., 2015).
How does professional development regarding technology integration provide support for STEM elementary school teachers?	SQ#2	Teachers will guide students to construct knowledge for themselves.

The research design for this study is basic qualitative. Basic qualitative was the most appropriate approach for this study because the purpose is to understand how elementary teachers integrate technology in STEM lessons. The purpose of conducting a qualitative research study is to explore "how people interpret their experience, how they construct their worlds, and what meaning they attribute to their experience" (Merriam & Tisdell, 2015, p.24). The overarching research question asks, how does the knowledge of STEM influence elementary school teachers' ability to integrate technology in STEM classes? This question relates to the idea of interpreting experience. The first subquestion relates to how people construct their worlds by asking, how do elementary school teachers utilize and integrate technology in STEM classes? The second subquestion relates to the meaning attributed to their experience by asking, how does professional development regarding technology integration provide support for STEM elementary school teachers? Based on this information, basic qualitative appeared to be the most suitable design for this research study.

There were considerations for other research approaches such as case study, phenomenology, and narrative, but basic qualitative research study appeared to be the most applicable. A case study qualitative research study was not chosen because the questions are "how" questions, and Yin (2014) asserts that "how" and "why" questions are likely to lead to a case study. However, these questions do not "seek to explain a circumstance or social phenomenon" (p., 4). These questions are also not about "a set of events in which there is no control" (Yin, 2014, p.14). A case study also is bounded by time and place, and this study was not bounded by time and place.

Phenomenology was another qualitative approach that was considered but not chosen because it is an approach that involves a reflective experience that is descriptive in nature (Moustakas, 1994). Phenomenology aims to seek what is meant by an experience and provide a description that is meaningful and concrete (Moustakas, 1994). A phenomenology approach intends to provide the deep meaning and essence of a lived experience of a phenomenon through long interviews. This study was not about the lived experience of a phenomenon. Instead, this study focused on elementary teachers' integration of various technology such as iPads, digital cameras, and laptops in STEM classes.

A narrative qualitative approach was also considered but not chosen because it is a story of a person's life. A narrative qualitative research design is a reflection of ideas or situations. It provides information about a person's experiences from a real-world setting to "accentuate a sense of being there" (Yin, 2014, p.17). Clandinin and Rosiek (2007) describe the narrative approach as a way of understanding another's experience through collaboration between the researcher and the contributor. This experience is shared over time, in a place or series of places, and through social interaction (Clandinin & Rosiek, 2007). In narrative qualitative research, the primary data is storytelling collected through "personal journals, photographs, artifacts, stories, chronologies, family interviews, conversations, and field notes" (Connelly & Clandinin, 2012). Therefore, the basic qualitative approach was selected because it explores the different ways elementary teachers integrated technology in STEM lessons.

Role of the Researcher

My role was that of an interviewer. I am an elementary school teacher in a school district in mid-South, Carolina. However, the district in which I teach is not part of the selection pool of participants. The choice of elementary teachers was chosen from school district locations where the researcher was not involved in any way. The only relationship is that we are all elementary teachers who teach STEM, and I do not occupy a supervisor position. All participants were selected purposefully and willing to participate on their own.

I have taught STEM lessons as well, so I had to remain unbiased and objective. Yin (2014) asserted that the researcher should be aware of any potential bias that may influence their understanding. As the interviewer, I could not allow my beliefs about STEM classes to influence and cause preconceived assumptions about STEM classes before and during the interview. Merriam and Tisdell (2015) revealed that it is critical for the interviewer not to argue and expose their personal position.

I interviewed elementary school teachers and followed up with them later to clarify any unclear points. As an interviewer, I first obtained consent to interview eight to ten teachers in the three different school districts in South Carolina. Patton (2015) assessed that small samples could not provide generalization but could provide a great deal of information for further research. Before I contacted the participants, I obtained permission from the Institutional Review Board (IRB). Once consent was granted from the IRB and the elementary school teachers agreed to participate, I discussed the study's extent with the participants. It was at that point that we decided upon the location to conduct the interviews.

Methodology

The methodology of this qualitative study is divided into sections that begin with the rationale for selecting participants. The next three sections are about the instrumentation, the procedures for the recruitment of participants, and the issues of trustworthiness. Details are provided in each section so that the reader has the necessary information to duplicate or extend the study. The methodology section consists of the data analysis section, which provides the plan for collecting and analyzing the data, followed by a conclusion.

Participant Selection Logic

The choice of participants for this study was from a population of public school elementary teachers who teach STEM classes in South Carolina. The research suggests that not many elementary schools have STEM classes (McKinney et al., 2017). The purposeful choice of participants was 8 to 10 elementary teachers from elementary public schools in the middle region of South Carolina. Ten elementary teachers were chosen so that the researcher collected rich, in-depth data. Patton (2015) suggested that minimum sampling for qualitative research is based on "reasonable coverage of the phenomenon given the purpose of the study" (p. 314). The state of South Carolina was chosen for convenience and time. According to Yin (2014), purposeful sampling is considered when the researcher chooses the participants deliberately in qualitative research. Merriam and Tisdell (2015) asserted that the researcher wants to gain insight into a phenomenon by using purposeful sampling.

This basic qualitative study used purposeful sampling because purposeful sampling was used for criterion-based selection (Merriam & Tisdell, 2015). The choice of participants was with the idea that these participants would provide the most valuable data for this study. The participants were chosen based upon several criteria.

First, they are elementary public school teachers who teach STEM lessons. These participants are teachers in an elementary public school in the middle region of South Carolina. The last criterion is that they teach students in the third through fifth grades. Merriam and Tisdell (2015) asserted that criteria are essential factors in purposeful sampling. Based on these criteria, I searched the South Carolina Department of Education website and retrieved a substantial school directory. The listing provided information about all of the schools in South Carolina. I had to sort through the list to select elementary schools that have teachers who teach STEM. I then contacted the principals of each of the elementary schools that employ teachers who teach STEM.

Instrumentation

The data collection instrument used for this study was an interview protocol created by the researcher. The interview protocol included several items to ensure the content is valid. The interview protocol (see Appendix A) included the interview guide, which described the interview process and the questions.

The overarching research question was, “How do elementary school teachers utilize and integrate technology in STEM classes”? Merriam and Tisdell (2015) stated that interviewing is necessary when one cannot observe the phenomenon. The knowledge of a teacher cannot be observed, so interviewing is the method of collecting data. Merriam and Tisdell (2015) conveyed that some types of questions should be avoided during the interview, including multiple questions, leading questions, and questions that provoke a yes or no response.

Table 2

Alignment to Interview Questions

Research Questions	Interview Question Number
How do elementary school teachers utilize and integrate technology in STEM classes?	1. What is your definition of technology? 2. Describe your use of educational technology background, such as iPad, Chromebook, digital camera, and desktop computer. 3. What are the different types of technology with which you are familiar? 4. Describe the different types of technology you have used in STEM lessons. 5. How were you prepared/educated to teach a STEM class?
How does the knowledge of STEM influence elementary school teachers' ability to integrate technology in STEM classes?	6. Describe your teaching background. 7. How many years have you been teaching STEM lessons? 8. Describe the STEM background knowledge you have. 9. How were you prepared/educated to teach a STEM class? 10. Describe what a STEM lesson looks like in your classroom.
How does professional development regarding technology integration provide support for STEM elementary school teachers?	11. Describe a professional development you attended regarding STEM lessons. 12. Describe a professional development you attended regarding technology integration in STEM lessons. 13. How does attending professional workshops affect your classroom instruction? 14. What kind of support did you receive after attending the professional development workshop?

According to Merriam and Tisdell (2015), interviews are semistructured when structured around several factors. These factors include a mix of questions, and with flexibility, the requirement of specific data from all respondents, the largest part of the interview has a list of questions for exploration, and there is no predetermined wording or order. There were at least two reasons why the researcher used a semistructured interview for this study. The first reason was that there was a mix of more and less structured questions created by the interviewer. The next reason was that there are specific data about STEM required from all of the participants. This semistructured format allows the interviewer to explore emerging ideas from the list of questions (Merriam & Tisdell, 2015).

Procedures for Recruitment, Participation, and Data Collection

After approval was received from IRB, contacting elementary teachers in the middle region of South Carolina who teach STEM was the next step. As the researcher, it was my duty to collect data from the chosen participants through interviews. Using the South Carolina Department of Education website, a list of schools was retrieved. From the list of over 1,200 schools in South Carolina, there was an elimination of the high schools, middle schools, magnet schools, private schools, and charter schools. I eliminated high, middle, magnet, private, and charter schools because these schools were not public elementary schools, and the focus of this study was public elementary school teachers. All of the elementary schools had to be sorted by geographical region. After identifying elementary public schools located in the middle region of South

Carolina, those elementary schools were called to see if the school had teachers who teach STEM classes. After identifying the elementary schools with teachers, who teach STEM lessons, the principals were notified by email to request permission to interview their teachers.

When the principal granted permission, a recruitment email was sent to the elementary teachers at the participating school. This email solicited approval to collect data from those elementary teachers who met the criteria stated in this study. The goal was to choose eight to ten participants from the middle region of South Carolina to interview. The invitation (see Appendix B) sent to teachers included the study's purpose and the phases of the data collection process. The respondents of this email then received the informed consent and privacy document (see Appendix C), followed by a telephone call to discuss the study's specific requirements, participant requirements, and other details. Other details included an option for the participants to choose the type of interviews, such as face to face (f2f), telephone, or Skype interview. The duration of the interview was 45-60 minutes. During this telephone call, there was also a discussion concerning the method of recording the interview, which I suggested to be audio.

If recruitment resulted in too few participants, the follow-up plan was to expand the selection beyond the middle region of South Carolina for potential participants. One week before the interview, participants received more information about the study and permission to stop at any point during the interview. At this point, we were amid a nationwide pandemic of a coronavirus COVID-19, which caused changes to the recruitment process. The initial participants were not responding due to the closure of schools. I proceeded to recruit teachers with the same criteria via social media. The ten interviews were conducted within a two-week time frame. The next week, transcribing took place, and participants were contacted for clarification if necessary. Participants were also allowed to contact me if they wished to enhance or retract any information they provided during the interview. One month after the interviews, a debriefing was done with the respondents. At this time, participants received a formal notice of appreciation, a copy of the interview with any additional information they had provided.

Data Analysis Plan

Data analysis involves collecting, interpreting, and making sense of data collected (Merriam & Tisdell, 2015). The collection of the data was transpired through Zoom Virtual interviews or email correspondence. The 10 participants who volunteered to participate in the study were interviewed using the researcher created interview questions (see Appendix A). The created questions were aligned with the research questions (see Table 2) and the conceptual framework (see Table 1). Zoom virtual interviews were conducted for about 45-60 minutes for two of the 10 participants. Email correspondence was sent and received from eight of the 10 participants. The data were analyzed by the researcher and then through the use of Microsoft Excel Spreadsheets.

The analysis of the data by the researcher was to transcribe the interviews from the audio recording. The researcher analyzed each interview recording after each interview. This analysis is done in an ongoing process, so the interviewer does not get overwhelmed with the mass amount of data (Merriam & Tisdell, 2015). By analyzing one interview at a time, the researcher could be introduced to other emerging themes, which leads to other questions to ask for the next interview. Each of the interviews was transcribed and coded using open coding. Open coding was used to analyze the data using categories derived from the first interview. In this qualitative study, no discrepancies were identified and explored with the participants as a way to check any possible bias and add to the concept of confirmability (Sutton & Austin, 2015).

Each interview was transcribed through a spreadsheet that, according to Merriam and Tisdell (2015), helps keep the data organized through the analysis process. The researcher uses three phases of data management when analyzing data (Merriam & Tisdell, 2015). These phases are data preparation, data identification, and data manipulation. The data preparation phase involves typing the notes and transcribing the interviews. The data identification phase involves assigning the codes to segments, and in the data manipulation phase, the segments are searched, sorted, and rearranged (Merriam & Tisdell, 2015).

Issues of Trustworthiness

The establishment of trustworthiness was addressed through the concepts of credibility, transferability, dependability, and confirmability. Each of these concepts was considered to ensure trustworthiness. Shenton (2004) explains that credibility is similar to internal validity; transferability is similar to external validity or generalizability; dependability relates to reliability, and confirmability relates to objectivity.

Credibility

Credibility was established by collecting data from elementary teachers in school districts south of the United States, where I am not involved. Credibility was addressed in the number of participants and the fact that they were all elementary teachers who teach STEM lessons. Before the interview, initial contact was made through emails and telephone conversations to establish familiarity with participants. Triangulation is another method of establishing credibility (Shenton, 2004). Triangulation was established through information obtained in the interview based on the different schools where the participants teach. Interviews were conducted in the Midlands from at least three different elementary public schools. The interviews conducted at one elementary school were cross-checked with the interviews conducted in the other elementary schools. Another way that credibility was established is through member checks. Each interviewee received a transcript of their interview to check for accuracy. The participants were asked to provide feedback to ensure accuracy. The feedback helps to ensure that the meaning of what the respondents said is not misinterpreted (Merriam & Tisdell, 2015). Another criterion for addressing credibility was reflexivity, which is a way to process the researcher’s biases. According to

Merriam and Tisdell (2015), the researcher should be aware of their "biases, dispositions, and assumptions regarding the research (p. 248). The researcher kept a notebook of biases, dispositions, and assumptions that surfaced before, during, or after the interview process.

Transferability

Transferability is a concept where a research report's findings can be transferred to other situations and populations (Shenton, 2004). Transferability was established through detailed, thick descriptions so that there is no misunderstanding. This description should include the setting, participants, and findings (Merriam & Tisdell, 2015). The amount of time for each interview provided rich data, which adds to transferability. The variation in the three different elementary schools used for participant selection also established transferability. The purposeful sampling of elementary school teachers who taught STEM as participants also established transferability.

Dependability

Dependability was established through detailed records of the data and notes. The researcher kept a journal of ideas, questions, and problems that were encountered during the study. This journal of ideas, questions, and problems became a part of an audit trail. Merriam and Tisdell (2015) describe an audit trail as collecting data, the result of the categories, and how decisions are made about the data (p. 252). The complete research study details, such as planning and strategizing, gathering the data, and the researcher's reflection, established dependability.

Confirmability

Confirmability was established through a reflexive journal where self-reflection was noted. The researcher answered the interview questions and wrote a reflection before interviewing the participants to be self-aware of any biases, preconceived notions, and assumptions. Using a reflexive journal throughout the research study provided an opportunity to bracket any feelings or biases that emerged during the interview phase (Merriam & Tisdell, 2015).

Ethical Procedures

The research can rely on the guidelines and regulations for some ethical situations that arise; however, the ultimate consideration of producing a qualitative study with ethical considerations relies on the researcher (Merriam & Tisdell, 2015). Research conveys that ethical procedures relate to trustworthiness through the researcher. The researcher is the basis of ethnicity in a qualitative research study and, therefore, responsible for carrying out the study in an ethical manner (Merriam & Tisdell, 2015. p.264). The researcher followed what Merriam and Tisdell (2015) considered the ethnicity checklist to address ethnicity, which included explaining the study's purpose. In addition to the purpose, the participants were also provided a document of informed consent and privacy agreement (Appendix C) to sign. The participants were provided with an explanation of the risk factors and information concerning storage for collected data. The researcher submitted an application to the IRB for permission to collect data.

After attaining approval from the IRB at Walden University, the recruitment of participants began. Initially, each participant was emailed an Informed Consent form as an invitation to the study. Once the participants agreed to participate in the research, the form was returned for an electronic signature. Before the interview, participants had a chance to discuss the Informed Consent (Appendix C) agreement to ensure they understood that they were volunteering and their information would be confidential. It was also clarified that they could withdraw from the study at any time and that pseudonyms will replace their names. The use of pseudonyms assures the participants that no identifying information would be disclosed to identify them.

This study's interview process was to be conducted in the participant’s school, and there were no power differentials because the researcher is a teacher as well. Because the researcher is also a teacher, there is an understanding that a teacher's available time is limited. All of the storable data (paperwork, videotapes, audiotapes, and any other materials) from the interviews are in a lockbox located at home. The electronic data is stored on a desktop as well as a laptop at home. Access to both of these devices requires a passcode. No one other than the researcher has access to this information. All of this information is kept for five years.

Summary

In this chapter, I discussed the methodology used in the research through different sections. In the research design and rationale, reasons were introduced as to why one design was chosen, and others were not. The methodology was sectioned to disclose information about the selection and recruitment of participants. This chapter also provided a discussion of the instrumentation, which involved the interview protocol. The issues of trustworthiness were thoroughly conveyed with a focus on credibility. There was also a section on data analysis where I discussed the steps taken to collect and analyze the data. In Chapter 4, I will provide the findings from the collection and analysis of the data.

Chapter 4: Results

Introduction

In this basic qualitative, I explored elementary teachers' integration of technology in STEM lessons. There was special attention given to the utilization of technology, such as digital cameras, iPads, and laptops. The focus of the study was elementary teachers' knowledge and training of STEM to promote learning in the classroom. In this chapter, I restate the research questions and describe the setting and demographics. Next, I discuss the data collection process, the data analysis, the themes and codes, and the discrepant cases. Last, I provide evidence of trustworthiness, results from the research questions, and a summary of the data.

This study was guided using a social constructivist framework, which is the foundation of problem-based learning and the following research questions:

RQ1: How do elementary school teachers utilize and integrate technology in STEM classes?

SQ1a: How does the knowledge of STEM influence elementary school teachers' ability to integrate technology in STEM classes?

SQ1b: How does professional development regarding technology integration provide support for STEM elementary school teachers?

Setting

In Chapter 3, I stated that the participants would have options regarding the type of interviews, such as face-to-face (f2f), telephone, or Skype interviews. However, in

March of 2019, during the recruitment phase, the world experienced a Global Pandemic of a coronavirus (COVID-19), which caused changes to the data collection process. Face-to-face was no longer an option due to a statewide shutdown of schools. Teachers had to transition to either blended learning or virtual learning. The respondents who had agreed to participate in the research study before the pandemic were given the option of email interviews, video conferences, or telephone interviews. Out of the six respondents at that time, only two continued contact with me, which led to a change in the recruitment process. The recruitment was through the South Carolina Department of Education, where I identified elementary public schools located in the middle region of South Carolina. The follow-up plan was to go beyond the middle region; however, the virus had a global effect. I then received permission to recruit via social media and word of mouth. I was able to recruit 10 participants for the study.

Due to the pandemic, everyone was at home as teachers were teaching online, and if they had children, they expressed that they would have to find time to respond. Through in-depth semistructured interviews of the 10 participants, two were interviewed through the Zoom video conference, eight via email. The participants were all teachers who taught in the middle region of South Carolina, and they all taught STEM lessons in Grades 3-5.

Demographics

In this qualitative study, I provided the demographics of participants who met the requirements of being an elementary public school teacher who teaches STEM lessons, teaches in an elementary public school in the middle region of South Carolina and teaches students in the third through fifth grades. Table 1 lists the pseudonym assigned to each participant by name, gender, race, interview method, grade levels taught, number of years teaching, and the number of years teaching STEM.

Table 3

Demographics of Participants and Grade Levels

Participants	Gender	Race	Interview Method	Grade Levels Taught	Years Taught	Years taught STEM
Angel	Female	African American	Email Correspondence	k-2	13	1
Brenda	Female	African American	Email Correspondence	5th	6	2
Caroline	Female	African American	Email Correspondence	3rd & 4th	13	2
Craig	Male	African American	Email Correspondence	3rd, 4th, & 6th	21	9
Glenda	Female	African American	Zoom Video Conference	Kindergarten & 4th	13	8
Larry	Male	White	Email Correspondence	7th, 8th, k-5	20	15
Mina	Female	African American	Email Correspondence	3rd	19	5
Nika	Female	African American	Email Correspondence and Telephone Conference	2nd & 3rd	6	4
Rebecca	Female	White	Zoom Video Conference	6th & 4th	9	11
Stella	Female	White	Email Correspondence	5th	25	6

Data Collection

The collection of data for this basic qualitative study came from one source. Using semistructured interview questions, I collected responses from ten participants who met the criteria of being elementary public school teachers in the middle region of South Carolina who taught STEM lessons in third through fifth grades. After receiving approval from the Walden University IRB (# 01-31-20-0172145) on January 30, 2020, I began to recruit participants for this qualitative study. In Chapter 3, I discussed how I would recruit participants for my study using the schools' directory from the South Carolina Department of Education website. Due to a worldwide pandemic of the Coronavirus (COVID-19), worldwide changes had to be made. The school systems revamped and went from brick and mortar to virtual learning.

The interviews that were scheduled to take place face to face were canceled or revamped. The recruitment procedure changed from the Department of Education website to social media and word of mouth. Eight to 10 participants were sought after to interview for this qualitative study. After about 3 weeks, I was able to recruit and connect with 10 participants.

Two of the 10 respondents were able to do a video interview. There was a Zoom one on one conference with each of these two participants. Each of the participants was working from home due to the worldwide pandemic. Because of the pandemic, I had time to connect with teachers a bit sooner than expected. It took about 45 minutes for the Zoom video conference with Rebecca but only 25 minutes to interview Glenda. Glenda responded to the questions efficiently, but the responses with Rebecca required more follow up questions.

The other eight participants opted for email interviews with back and forth correspondence for 2 weeks except for Larry, who took 3 weeks to respond. One of the teachers who did email correspondence followed up with a telephone interview for clarification. The follow-up questions were through email correspondence and took a bit of time to receive responses because the email accounts were school email accounts. Participants made it known when they responded that they do not check school email accounts as often when school is not in session. The turnaround for the responses from the follow-up questions was usually within 2 weeks except for Rebecca, who took 3 weeks to respond, and Larry, who did not respond to the email follow up.

Data Analysis

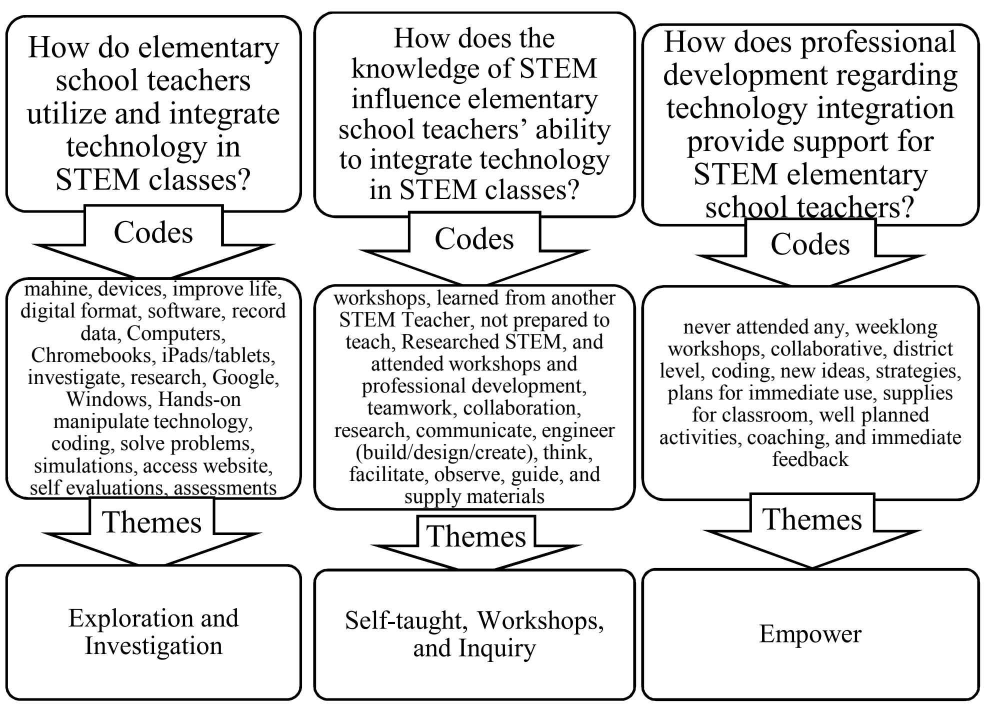
For this basic qualitative study, I conducted data analysis using the Microsoft Excel spreadsheet. I used open coding with a Microsoft Excel Spreadsheet due to flexibility. Data analysis is comprised of "consolidating, reducing, and interpreting" data collected (Merriam & Tisdell, 2015). I began coding with the spreadsheet using color coding for each of the 10 participants and their information so that it was easier to connect each participant to their responses. After assigning each participant a color, I began to create codes to organize the data collection. After the creation of the codes, I created categories to organize my codes. After each additional interview I received through email, I looked for the same or similar codes from the first interviews and found some of the same codes and some new codes. I then sorted the codes into categories, and the similar codes were placed into the same category. I took some time to re-read previous chapters, then revisited my codes and categories. I combined and changed some codes and deleted some similar categories. At the end of this process, I combined the categories into themes. By the end of my data analysis, I narrowed down the categories into five themes.

Themes and Codes Related to Research Questions

In this section, I will discuss the categories and themes from my analysis of the data. The findings of the study relate to the research questions of this study. The analysis of each question presents the codes and the theme that was found.

Figure 1

Relationship Between Questions, Codes, and Themes



The first set of research questions sought to explore how public school elementary teachers use technology during STEM. Some of the participants' questions included asking about their definition of technology and the types of technology they have integrated in STEM lessons. During the analysis process, similar responses were grouped and coded. The codes that emerged from the respondents for the definition of technology questions included “machine,” “devices,” “tools,” “improve life,” “digital format." The codes that emerged from the respondents for the types of technology questions include "software," “Google,” “Windows,” “Computers,” “Chromebooks,” “iPads/tablets." Other codes that emerged from the respondents included “record data,” “investigate,” “research,” “hands-on," “manipulate technology,” “coding,” “solve problems,” “simulations,” “access website,” “self-evaluations,” and “assessments." All of these codes presented the themes of exploration and investigation.

The second set of interview questions sought to explore if elementary teachers’ knowledge of STEM affects their ability to integrate technology during STEM lessons. Participants were asked about their background knowledge of STEM, and the most common response was “workshops." Participants were also asked how they were prepared to teach STEM lessons, and the most common responses were “learned from another STEM Teacher,” “not prepared to teach,” “Researched STEM,” and “attended workshops and professional development." The participants were asked to describe a STEM lesson, and the most common responses were divided into teacher and student responsibilities. Student responsibilities included: “teamwork,” “collaboration,” “research,” “communicate,” “engineer (build/design/create),” “think.” Teacher responsibilities include "facilitate,” “observe,” “guide with questions,” and “supply materials." From the codes, the emerging themes were Self-taught, Workshops, and Inquiry.

The third set of interview questions sought to explore how STEM professional development for technology integration supports elementary school teachers. Participants were asked to describe various professional developments they attended regarding STEM and technology integration. The common responses were “never attended any,” “weeklong workshops,” “collaborative,” “district level,” and “coding.” They were also asked how attending professional development affected their classroom instruction. The common responses were “new ideas,” “strategies,” “plans for immediate use,” “supplies for the classroom,” and “well-planned activities.” Responses for the kind of post support they received from the professional development included "coaching" and "immediate feedback." Empower was the only theme that emerged from the codes.

Evidence of Trustworthiness

I adhered to specific processes in the recruitment of participants and the collection and analysis of the data. All of which provided necessary guidelines to establish trustworthiness. The establishment of trustworthiness was addressed through the concepts of credibility, transferability, dependability, and confirmability. Each of these concepts was considered to ensure the trustworthiness of the study.

Credibility

I followed the data collection process presented in the methodology section of this study to ensure credibility. Credibility was also established by collecting data from elementary teachers in the school districts in the middle region of the south, the number of participants, and the fact that they all teach STEM lessons. Triangulation, which is another method of establishing credibility (Shenton, 2004), was established through the interview process's information. Each interview conducted via video conference or email correspondence was from different elementary public schools and was cross-checked to ensure credibility. Another way that credibility was established was through member checks, where each interviewee received a transcript of their completed interview to provide feedback to ensure accuracy and eliminate misconceptions (Merriam & Tisdell, 2015). To minimize my biases, I kept a spreadsheet of notes and data analysis. According to Merriam and Tisdell (2015), the researcher should be aware of their biases when dealing with research.

Transferability

Transferability was established by providing detailed, thick descriptions so that there is no misunderstanding. The detailed, thick description includes the setting, the participants, data collection, and the data analysis (Merriam & Tisdell, 2015). The setting changed due to COVID-19. Two participants chose Skype video conferences from their homes, and the others opted for email correspondence. The participants were chosen through a purposeful sampling of elementary teachers who met certain criteria.

The criteria included elementary public school teachers in the middle region of South Carolina and who taught STEM lessons. The variation of the different elementary schools used for participant selection helped to establish transferability.

Dependability

Dependability was established through detailed records of data and notes. I kept a spreadsheet of ideas, questions, and problems as part of an audit trail to display the result of the categories, codes, and how the decisions are made (Merriam & Tisdell, 2015). Ravitch and Carl (2016) indicated that dependability is having a logical argument for the data collection method. The details of the study, such as the planning for the interviews, the strategizing of time, the process of gathering the data and analyzing it, and the researcher's reflection, established dependability. Ravitch and Carl (2016) stated, “a solid research design is the key to dependability” (p. 196).

Confirmability

Confirmability was established through reflexive notes where self-reflection was noted. A researcher’s bias is an important aspect of qualitative research that must be scrutinized, problematized, and complicated (Ravitch & Carl, 2016). I answered the interview questions and wrote a reflection before interviewing the participants. This process made me self-aware of any biases, preconceived notions, and assumptions that I may have had regarding STEM lessons. Ravitch and Carl (2016) indicated that reflexivity should be used throughout the data collection and analysis process to ensure confirmability. I was able to examine and confront any biases using notes. I could bracket any feelings or biases using a reflexive journal with notes throughout the research study (see Merriam & Tisdell, 2015).

Results

The results are organized according to the three research questions' analysis and the themes that emerged from the responses. The 10 participants responded to the questions, and the results were analyzed through coding. Once the analysis began, patterns started to develop, and from the patterns, themes emerged. The development of the themes is reported below based on the question.

Research Question

The research question was, how do elementary school teachers utilize and integrate technology in STEM classes? In this study, technology is described as instructional tools or devices such as iPads, laptops, and digital cameras. There were semistructured questions that helped to guide the three research questions. These questions included the definition of technology, technology background, and the different types of technology for which the teachers are familiar. Exploration and investigation are the two themes that emerged from the participants' responses to the research question.

Exploration

The 10 participants that were interviewed gave varied descriptions of technology. Some of the participants described technology as using machines, tools, or devices to make life easier. Of the 10 participants, five defined technology as a computer or digital device. For example, Craig stated:

> Technology is utilizing resources (computers, phones, internet, etc.) that allow people to connect globally using a digital format.

Other participants presented similar definitions of technology, which included using technological devices. Glenda and Rebecca responded with the definition of technology as something created to help improve life, not as a device or tool. They emphasized that it helps to improve the quality of life. For example, Glenda wrote:

> Well, technology is something that is created to make life easier. So, For instance, I believe a chair requires to help us to be able to sit down comfortably without, you know, sitting on the floor, a fork is required to help us pick up food so we can eat.

Rebecca expressed a similar definition when she stated:

> I think basically, technology is just, you know, finding a way to creatively improve our lives using our scientific knowledge, our scientific innovation. It's about yea; it's about finding creative solutions to life challenges and doing things using the knowledge that you have and combining the knowledge in order to improve the way that we do things on a daily basis. Little things to big things.

When asked about their educational technology background, there were varied responses from the participants. Some participants expressed that they had no formal technology training, so their technology use was limited. However, Rebecca articulated having various training in educational technology. Larry shared that he has a doctorate with a minor in educational technology. Caroline and Mina communicated that they have attended technology integration classes in either professional development or graduate school and expressed being great with using technology. Craig specified being “technology savvy” due to the South Carolina teacher’s certification demand for technology proficiency in the state. Although Glenda's previous career was behind the scenes in television working with computers and cameras, educational technology's inadequacies were expressed. All the participants disclosed that they had utilized different educational technology types such as iPads, Chromebooks, digital cameras, and desktop computers in the classroom.

Investigation

Participants expressed that they utilized educational technology devices in the classrooms. However, there were diverse differences in how they were utilized in the classrooms, which led to this second theme, “investigation.” Educational technology devices such as iPads, Chromebooks, and desktop computers were explicitly named as more useful with different websites. These technological devices were used to research, create, code, and assess students. Glenda specified that technological devices were used mainly for research in STEM lessons. Glenda stated:

> I use computers in my classroom for research purposes, interactive simulations of projects unable to do in person, recording of discussions and reflections, taking pictures or videos of work in progress or completed assignments, and

> assessments to check for student understanding. A website I love to use is sciencekids.co.nz. This website allows students to choose from doing experiments at home and games they can play that deal with concepts learned in class. In class, we use the games section to utilize the interactive simulations.

Nika expressed that computers were used to create presentations, and Brenda agreed with Nika but added that she used them to make, edit, and present movies. Participants also used computers to assess students' work. Mina, Larry, and Caroline indicated that they used educational technology devices such as iPads, laptops, and desktop computers for coding. Caroline expressed that students could use iPads, laptops, and computers to create lessons using Scratch, comparing fractions. Caroline wrote:

> They also had an opportunity to build a robot and have their very own robot mimic animal behaviors but acting like that particular animal. Before the pandemic occurred during the 2019-2020 school year, students were in the process of creating codes in Minecraft, where they had an opportunity to program their very own agent to perform certain tasks.

Research Subquestion 1

The first subquestion was how does the knowledge of STEM influence elementary school teachers' ability to integrate technology in STEM classes? Participants were asked a set of questions about how they were prepared to teach STEM lessons and what a STEM lesson looked like in their classrooms. The three themes that emerged from the participants' responses were self-taught, workshops, and interaction.

Self-Taught

The theme self-taught refers to one method the participants used to gain knowledge of STEM lessons. Some of the participants expressed that they had no formal training to teach STEM. Without formal training, Glenda, Nika, Angel, and Brenda described being unprepared to teach STEM. Brenda wrote:

> Honestly, I do not believe I was truly prepared to teach STEM. Most of what I know I've learned after college through workshops, professional development, and my own research. I've talked to a lot of enthusiastic science teachers and spent a lot of time experimenting to see what works best and what doesn't.

Some respondents specified that they learned from other teachers or researched STEM online with no formal training. Glenda and Angel described learning about the STEM process through guidance from another teacher who taught STEM. Angel wrote:

> I really do not feel as though I was prepared or educated to teach STEM. As a graduate of 2007, the focal point definitely was not science at the time. However, we have evolved into this. I really saw the need for STEM and how fun and engaging it could actually be when my school at the time had a STEM teacher. A role that I feel is undervalued and much needed in all schools today. It was in that role that I saw the teacher bring life to our science standards. I believe

wholeheartedly; it was because she had the time, space, and materials to focus specifically on the STEM activities.

Rebecca, Stella, Caroline, Craig, and Larry indicated that they learned STEM through school or various professional development programs. Rebecca stated:

> I was at UC Santa Barbara, which is a research institution, and the science and engineering side of that school was heavily emphasized versus the arts you know the other side. So, when I became a science teacher and was doing my education, there was a lot of emphasis on STEM. When I became a teacher, a teacher in my first district, and even especially now being in SC, it's been hard to find professional development that really focuses on STEM, so I haven't felt since becoming a teacher like I have been encouraged to learn as much about it.

Caroline expressed learning about STEM lessons somewhat differently by writing:

> I was prepared to teach STEM lessons by attending various professional developments offered by my school district and my current school specifically. Because we just transitioned into a computer science immersion school, a lot of our school-wide professional developments for this year has been geared towards that purpose.

Some participants explained that their lack of learning about STEM placed limitations on their knowledge of STEM, but they continued seeking information to teach STEM lessons. They expressed that they desired to teach STEM lessons, so they sought out methods to teach them. Mina had received no formal training; however, STEM knowledge was gained through reading. There was not another teacher, no professional development, or any online classes. The methods and strategies used for teaching STEM lessons were obtained through reading literature concerning STEM lessons.

Workshops

This theme emerged from analyzing the data collected, where the participants provided descriptions of their methods of learning about STEM. Most of the participants described workshops as their only method for learning about STEM lessons. They expressed that they have attended workshops and classes to learn as much as they could about STEM. Caroline wrote:

> STEM is a curriculum based on four specific disciplines: science, technology, engineering, and mathematics. Currently, my background knowledge falls in the technology portion of the STEMS component. My school is currently integrating computer science programs into student's everyday curriculum. Furthermore, my district is also focusing on the 8 Science and Engineering Practices such as asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using conceptional things, constructing explanations, engaging in thoughtful conversations, and communicating information.

Brenda had similar comments to Caroline's response. Brenda wrote:

> I was invited to spend a week in Greenville, SC, with Science PLUS learning strategies to engage students in STEM. We focused on using engineering practices throughout our lessons and integrating technology as a learning tool - not just for assessment. I have also attended STEM-based professional development offered by the district.

Inquiry

This emergent theme was developed during the phase of data analysis. The participants described how they integrated digital technology such as iPads, Laptops, and Digital Cameras in a STEM lesson and what it looked like in their classroom. Some participants provided information about what students would be doing and what the teacher would be doing during the lesson. STEM lessons were described as engaging and thought-provoking. Several participants agreed that these lessons required hands-on and collaboration. However, not many expressed the integration of educational devices. For example, Rebecca stated:

> So it involved a lot of the kids generating the question first obviously with my encouragement and then them coming up with the ideas about how to solve that problem and with those prompts you know I was, and I think that actually was done on Day 1, and so then I was able to go and supply the appropriate materials and the next day coming in saying okay guys, so we came up all these ideas so here's what we gonna try today and here's what you have available to you and here's what we decided yesterday what the end goal was and then kind of

allowing them to just oh you have an hour right now let's see what you come up with and I think involving the kids in the process of building the questions, building their ideas, you know building their solution. That's the major component of a STEM lesson allowing the students to have a hand in it again because we all know that if you're told, hey here's 6 of this thing and 5 of this thing go head build this thing okay, I either can do it or not, but you're not really learning a whole lot about the process of why you're doing it and that what STEM is is being creative and trying to come up with solutions to thing trying to challenge them to think creatively.

Rebecca described how she facilitated STEM lessons in her elementary classroom. She explained that the STEM lesson occurs over a couple of days, not just one day. Her process for teaching STEM lessons is a student-centered structure, which gives the students more choices in their learning. She continued:

So, when the kids actually get started, it's a lot of teamwork, it's a lot of collaboration. I want them to have productive struggle and not frustration there, you know coming up with ideas and sharing they're sending one person from their group over to another group to ask them questions scientists share things, and I emphasize that a lot. Scientist and learners, in general, share their ideas in their learning; we don't exist in a vacuum you know as society, if we're trying to improve our lives, we communicate. So, making it meaningful to them, you know, making it important and then kind of just allowing them to go.

Other participants described STEM lessons they taught in their classrooms, which involved integrating educational technology such as iPads, laptops, and digital cameras. Glenda stated:

> STEM lesson in my classroom obviously is student-centered. The students would be working in groups collaboratively, working on whatever project that I give them to do. You know, get them, let me see, to dig deeper. I can't even think of an actual STEM activity to give as an example. But they'd be trying to develop a solution to the problem that I've given them, and they'd be communicating with one another trying to engineer possible solutions to solve the problem. Research, if possible, if needed, kind of thing I would be walking around assisting as needed. Because I am supposed to be the facilitator, I'm not supposed to take over and tell students how to do something. I can guide them in the right direction if need be. His is an activity that I have done during the summer programs. Students are told that they will be engineers today. The students will listen to a recording where they are challenged to construct a tower that will save the animals from the hungry alligators. The students are presented with the challenge that the animals need to be at least 10 inches above the alligators to be out of their reach. I discuss with students the engineering design process and how it works.

Glenda described one STEM lesson she teaches with students where technology is utilized for research. She explained that she used an engineering challenge where students work collaboratively to solve real-world problems. Glenda allows students time to complete different aspects of the STEM lesson. She explained:

> The students are already sitting in groups and are given time to research buildings and towers on their laptops from the videos provided by myself and how they are constructed in the real world. Students are provided with index cards to test out various ways that are provided to them (roll the cards, fold the cards, or cut the cards) and discuss which option they would like to use to construct their towers. The question they are trying to answer is, "Can you imagine any ways you could use these materials to engineer a tower?". I show students the small stuffed animal that will be placed on top of their towers to see if it will be strong enough to hold its weight for at least 10 seconds. Groups are then given time to plan and create their towers. During this time, I walk around and assist students as needed by asking questions. I also allow students to hold the small stuffed animal in their hands to see how heavy it is. After about 20 minutes, groups will showcase their towers and discuss how they built it.

The STEM lesson Glenda described presents the students as engineers. The students go through a process similar to that of an engineer. They are allowed to test, revamp, and reflect. She explained:

> After each group presents, their towers are put to the test to see if they are tall enough and strong enough. If the tower holds for ten seconds, students are challenged to build their towers higher. If the tower doesn't hold, students are

> given the chance (based off of listening to their classmates) to build a stronger and better tower. Students will once again showcase their towers and discuss any changes they may have made to make it better. The conclusion we come to is that the wider the base of the tower, the stronger the tower will be. They also discover that the fold and cut it methods work the best. Students normally have the tower start off with a wide base, and it becomes narrow with each story or floor, or they will build the whole tower wide. (I hope this makes sense). Students reflect on what they learned today. I ask them what steps of the engineering design process and why it is important to follow these steps. I then allow them time to write their thoughts in their journals after they discuss it in their groups.

Angel, Brenda, Caroline, and Craig expressed similar responses. Every STEM lesson shared showed some of the same characteristics utilizing the technology aspect. Although the responses were similar in using technology, Craig explained STEM lessons in a different classroom setting. He wrote:

> One example of a STEM lesson would be a lesson on rock explorations. I would have STEM stations set up to make sure all components are covered. For example, the Science station would be a hands-on station where students are exploring and comparing different types of rocks. The technology station would allow students to use the Chromebook (laptop) to research something such as how can the rocks be used to make different building materials. The engineering component would be to design a neighborhood and include the use of rocks in it

(roads, sidewalks, etc.), and the math component would be to take measurements and compare the sizes and weight of different rocks.

STEM lessons incorporate the subjects of science, technology, engineer, and mathematics interchangeably. The participants explained the lessons they taught, which addressed the four disciplines of STEM. The lessons the participants shared noted that the teacher was the facilitator, and the students were the collaborators who work in teams to complete a task that is assigned to them.

Research Subquestion 2

The second subquestion was how professional development regarding technology integration provides support for STEM elementary school teachers? The one theme that came from the analysis of the set of questions about professional development was empowerment. Professional development was described as exciting, engaging, and beneficial.

Empowerment

This theme came from the questions where the participants described various professional developments and their instructional effects. Most participants never attended professional development for STEM with technology integration. Some participants did attend STEM professional developments without the component of technology integration. Glenda, Angel, and Mina did not attend any STEM professional developments but expressed that it was substantially important. They expressed that if they had the opportunity to attend, the sessions would provide them with feedback from their instruction. Mina wrote:

> In general, attending PDs gives me new ideas that I can take into the classroom, reaffirms what I am doing correctly and should, therefore, continue doing, and allows me to see what I'm doing incorrectly and should change.

Glenda stated:

> I believe it's important to have it, though. If anything I what I appreciate about professional development is that it allows me to get more comfortable with what I am trying to do with the students, and then I would have actual more confidence in what I'm doing to be able to make sure its effectively going you know the way it's supposed to because when you're in there and you're just doing what you're doing you have no idea if it the correct way if you haven't been taught.

The participants that attended Professional development for STEM described attending weeklong workshops with engaging strategies. Participants expressed that they receive supplies or resources from these workshops to use in their classrooms. Brenda wrote:

> Science PLUS was the best PD I've ever had in STEM. This is a statewide professional development at Roper Mountain in South Carolina. We learned so many engagement strategies, and we were introduced to so many resources. We also used Mystery Science and the Drain the Ocean docuseries to explore landforms and oceans. I still use my PLUS notebook to plan for lessons now.

Mina and Nika attended Science Plus as well. Through the provision of ideas, resources, and strategies, participants expressed that professional developments helped with their classroom instruction. They were able to replicate the STEM lessons in their classrooms. Craig wrote: "I gain valuable knowledge and ideas on how to implement ideas in my own classroom." Mina and Stella agreed with Craig, adding that it boosts instruction. They expressed a renewing of energy after an excellent professional development. Some participants also explained that they had received support from many levels after attending workshops.

Discrepant Cases

For this qualitative research study, participants' responses did not show any discrepant cases. The ten participants provided responses based on the interview questions, and data were analyzed and coded. After carefully reviewing the interviews, the participants' responses, and the notes I made, it was concluded that there was no evidence of discrepant cases.

Summary

In this chapter, I provided the research questions that were used in the interview process. I described the setting and demographics. I explained the data collection process and explained the themes and codes that emerged. Then I described evidence of trustworthiness through credibility, transferability, dependability, and confirmability. Last, I explained the results by research question and addressed any discrepant cases.

This study's key findings indicated that elementary public school teachers utilize technology such as digital cameras, iPads, and laptops in STEM lessons. Digital Cameras were used to take pictures for finished products. iPads and laptops were used to research information and to work collaboratively on documents.

It was found that technology was integrated into STEM lessons based on the teachers' knowledge of STEM. Another key finding was that some participants were not very knowledgeable of technology integration in STEM due to little or no training. Some participants had received no prior training for teaching STEM lessons, so their knowledge of technology integration was limited.

The final key finding was that participants did receive support from regular professional development whenever they attended sessions. It was found that many teachers did not attend a PD regarding technology integration in STEM lessons. Some teachers expressed that they would love the opportunity to attend sessions with technology integration but had never been offered an opportunity.

The first set of questions focused on how elementary school teachers utilize and integrate technology in STEM classes. The data was analyzed, and it produced two themes: exploration and investigation. These themes conveyed evidence of how elementary public school teachers use technology in STEM.

The second set of questions focused on how elementary school teachers' knowledge about STEM influenced their ability to integrate technology in STEM classes. The data collected from these questions provided three emergent themes: self-taught, workshops, and inquiry. These themes convey evidence that being knowledgeable about STEM is essential for elementary teachers to integrate technology in STEM.

The third set of research questions focused on professional development regarding technology integration and support for STEM elementary school teachers. One theme, empower, emerged from the data that was collected from the questions. This theme provided evidence that support for STEM elementary school teachers regarding technology integration is necessary.

In Chapter 5, I will provide the interpretation of the findings from Chapter 4, the limitations of the study, the recommendation for future studies based on the data obtained, and the implication for positive social change.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this basic qualitative study was to explore elementary teachers' integration of technology in STEM lessons. In this basic qualitative study, I explored elementary teachers' integration of technology in STEM lessons. This study was conducted to address the gap in the literature concerning public school elementary teachers and the integration of technological devices in STEM lessons. Specifically, this basic qualitative study involved 10 elementary public school teachers who taught third through sixth-grade students. All participants taught STEM lessons in elementary schools located in the middle region of South Carolina. This study's key finding indicated that the integration of educational technology such as digital cameras, iPads, and laptops in STEM lessons was limited. The participants had limited knowledge regarding integrating technology such as digital cameras, iPads, and laptops in STEM lessons. They had limited access to professional development for STEM lessons. The results provide the groundwork for the interpretation of the findings.

Interpretation of Findings

I interpreted this study's findings by considering Vygotsky's socioconstructivist approach and the literature review in Chapter 2. Through the literature review, it was indicated that there was a gap in the literature concerning the integration of technological devices in STEM lessons for elementary school teachers. Vygotsky's socioconstructivist approach suggests that children learn through engagement in social activities. Through

Vygotsky's socioconstructivism approach, I was able to create three research questions. The results from the data analysis were structured based on the three research questions and the themes that developed. The findings are aligned with the following themes: STEM, professional development for teachers who teach STEM, Educational Technology, and the integration of technology in STEM, which are some of the concepts from the literature review in Chapter 2.

STEM

Ring et al. (2017) suggested that teachers' knowledge and beliefs about STEM education influence the quality and integration of STEM lessons. The researchers indicated that STEM lessons are effective when the teacher is knowledgeable about STEM education and what it should look like in the classroom (Ring et al., 2017). I interviewed 10 elementary public school teachers who teach STEM lessons. Of the 10 participants interviewed, six attended schools or classes for teaching STEM lessons, which confirms the research. The six participants expressed that a STEM lesson is student-centered with the teacher as the facilitator. They explained that students worked collaboratively in STEM lessons. The other four participants shared that they learned how to teach STEM lessons by observing other teachers, using online resources and literature. Those four participants admitted having no formal training but a desire to teach STEM lessons. However, those participants felt unprepared to teach STEM lessons due to the lack of proper training, which extends the knowledge of EL-Deghaidy et al. (2017), who found that teachers were underprepared when it came to teaching STEM lessons in the classroom. The findings extend the knowledge of Scalise's (2016) study, which found that without a curriculum for teachers to use to teach technology skills, they develop their own.

Professional Development for Teachers who Teach STEM

According to Darling-Hammond et al. (2017), professional development should be useful for teachers. The result of my research extends the literature on effective professional development that would focus on content, incorporate active learning, support collaboration, use models of effective practice, provide support, feedback and reflection, and provide sustainable duration (Darling-Hammond et al., 2017; McComb & Eather, 2017). Participants who attended professional development geared directly towards STEM content indicated that the sessions were beneficial for them. Professional developments that were most effective in the participants' professional growth involved active learning, collaboration, and feedback. Respondents expressed that they were able to become "learners" and work collaboratively. These study findings confirm Darling-Hammond et al.'s (2017) research, which indicated that effective professional development features active learning, is collaborative, and content focused on a specific discipline(s). My study's findings expressed the participant's description of their participation in STEM-oriented professional development. The STEM professional development was described as engaging, informative, and reflective. Stella explained that the professional development session began with an explanation of the purpose and the benefits of STEM. She stated that the teachers could take on students' roles to get an idea of what the students in their classrooms would be doing in the lessons. The teachers worked on activities in groups or with a partner to understand the process better. Teachers were taught about different resources for STEM lessons and how they would utilize those resources. They also learned that the teacher is the facilitator and can be used as a resource after their students have exhausted all other possibilities.

Educational Technology

Kormos (2018) found that there is a digital divide in the utilization and the perception of the effectiveness of technology among teachers. When respondents were asked their definition of technology, there were differences in responses. The responses confirm Constantine et al. (2017), who found that teachers described technology as a tool to enhance students' learning or make life easier. Some participants described technology as a tool or device. Others described it as anything that improves life. This difference in responses also confirms Kormos' (2018) research in the sense of a digital divide. However, although the definitions were divided, the participant's utilization of technology in the classroom was similar, which disconfirms Kormos' (2018) research. The findings indicated that all study participants were familiar with a vast selection of technologies and utilized technology in their classrooms. The participants stated that they used digital devices such as iPads, Smartboards, Chromebooks, laptops, document cameras, and digital cameras in their classrooms. The participants did not integrate technology in the same manner, but they integrated technological devices in the classroom for the same purpose of teaching and learning.

Some participants described using various applications like EPIC, Seesaw, Flipgrid, Plickers, Quizziz, iMovie, Powtoon, Minecraft, and Scratch. The participants indicated that these applications are used for different reasons. For example, the participants' students would use Powtoon or iMovie to create videos to summarize what they learned in class. The use of applications is interesting because Estapa et al. (2017) found that technology is useful in the classroom for exploring various applications like Scratch, Alice, Kodu, and Greenfoot, which confirms my study.

The Integration of Technology in STEM

My results showed that elementary public school teachers integrated various technological devices differently when they teach STEM lessons. It was found that teachers integrated technological devices at different times during STEM lessons. These findings support Constantine et al.'s (2017) study, which found that teachers had different beliefs about how technology should be utilized in STEM lessons. The researchers found that technology was utilized in STEM depending on the context, teacher beliefs, and teacher practices. Several participants described students utilizing technological devices such as computers, iPads, and laptops to research before beginning a STEM lesson. Others indicated that students utilized technology to summarize their learning at the end of the STEM lessons. One teacher expressed that technology was integrated in STEM lessons for mapping, measuring, and data visualizations.

The participants provided descriptions of what a STEM lesson would look like in their classrooms. Most of the participants indicated that the students would work collaboratively, and they would be the facilitator. They all indicated the integration of technology at some point in their STEM lesson. One teacher described a STEM lesson that began with students using laptops to research how architects build tall stable structures. Then the students applied that information to create and execute a plan to build a tower with limited supplies. As they worked, the students utilized a computer to record materials and list the steps taken to complete the assigned task. This finding extends Scalise's (2016) study, which indicates how, when, and why technology is implemented in the classroom can improve student learning.

Another teacher described a lesson where students were collaboratively working on a coding activity. The students created a robot track; however, it took a much longer time to complete the assignment due to time constraints. The students worked on the task once a month for 1 hour at the end of the day. It was found that some of the participants had to find time to implement STEM lessons. Another teacher described an inquiry lesson on changing states of matter. Students used the website sciencekids.co.nz to conduct an experiment to see how a solid ice cube changes to a liquid. After the online investigation, students discussed what they have learned about matter. This website was described by a participant who explained that it allows the student to become responsible for their own learning. These differences confirm Asunda and Walker's (2018) research, who found that STEM is not the same at all schools because of different factors like populations and students' needs.

Limitations of the Study

This basic qualitative study was conducted to explore how elementary school teachers integrate technology in STEM lessons. Guided by the methodology of this basic qualitative study, there were limitations of the study, which impacted the results. The methodology included conducting interviews with 8-10 elementary public school teachers in the middle region of South Carolina. Ten teachers were chosen to ensure rich, in-depth, and detailed data collection. Semistructured interview questions were used to gather data in regard to the utilization of technology in STEM lessons. My initial plan was Face to Face interviews; however, due to unforeseen challenges, the process of interviewing changed.

Transferability was one limitation because all the participants were teachers from the middle region of South Carolina. Only 10 participants are elementary public school teachers, which is not representative of a larger population of teachers. This study's results may not represent schools in other regions of South Carolina or other states in the country.

Another limitation was the 10-week time constraint that was set for the data collection. As I began the recruitment process to collect data, I encountered another limitation. Due to a worldwide pandemic of a coronavirus COVID-19, it was no longer feasible to collect data face to face. COVID-19 presented location constraints and technology constraints. Data was collected differently depending on the teacher's availability. Two participants could meet virtually; the others could not, so email correspondence was the measure taken to collect data. Researcher bias was another limitation addressed through reflective journaling before the interview process to bracket any personal feelings and minimize researcher bias.

Recommendations

Listed below are the recommendations which could add to the groundwork of future studies.

- Conduct future research about STEM at the middle school level. Middle school students are close to an age where they make choices about careers. The research study could focus on why students choose STEM careers.
- Conduct future research about how STEM lessons are taught in private schools. Private schools may teach STEM lessons different from public schools. The research study could provide data concerning how STEM lessons are taught in private schools versus public schools.
- Extend the research on how elementary teachers teach STEM lessons with technology in other South Carolina regions. Since this study only involved the middle region of South Carolina, the research study could provide data concerning the upper region or the lower region of South Carolina.
- Extend research as to how STEM lessons are taught in the United States. South Carolina is one state in the United States. The research could be

conducted to provide data concerning STEM lessons in other states in the United States.

- Future studies could focus on teachers' perceptions of professional development to enhance their teaching of STEM lessons. Professional development plays a role in teachers' growth. The research could be conducted to get teachers' feedback on different professional developments of STEM lessons.
- Future studies that address the student's perspective of STEM lessons. This lesson focused on teachers who teach STEM. Future research could provide data about how students perceive STEM lessons.

Implications

Positive social change is implicated from the results of this study. Technology is ever-changing and has taken its place in the classroom. This study indicated that elementary public school teachers utilized technology in STEM lessons. Plenty of money has been invested in STEM so that teachers are equipped to teach STEM lessons (U.S. Department of Education, 2020). "In November 2019, it was announced that nearly $540 million was invested to support STEM education" (U.S. Department of Education, 2020). Although funding has been provided, the elementary school teachers have not been provided with the professional development that would equip them with confidence and the training need to integrate technology into STEM lessons.

This study contributes to positive social change for the student, the teacher, and the community, who are all stakeholders in elementary schools. Social change is inevitable when students are first introduced to technological devices such as iPads, laptops, and digital cameras. The U.S. Department of Education (2017) concluded that there is a digital use divide that continues to exist, but students are finding creative ways to utilize technology. The achievement of STEM goals set forth with the proper utilization of technology could impact the number of students entering STEM careers. This study suggests that teachers are guides or resources for students who collaborate during STEM lessons to achieve specific tasks. Teachers can provide students the guidance necessary for success with technology usage.

This study contributes to positive social change at the teacher's level through effective professional development for STEM lessons. This study indicated that teachers who have effective professional development were more confident in teaching STEM lessons with the integration of technology on several levels. Professional development could increase teacher’s self-efficacy so that they were more apt to implement STEM effectively (Gardner et al., 2019). The outcome of this study could provide justification for teachers to receive effective professional development on integrating technology in STEM lessons, improving teachers' confidence in teaching STEM lessons. Many elementary school teachers are already transitioning to being a facilitator in the classroom to make their classrooms more student-oriented. Technology-enhanced professional developments could help educators to become better facilitators, guides, and motivators of learners (U.S. Department of Education, 2017).

This study also contributes to positive social change within the community. STEM involves critical thinking and implementing various tasks that focus on issues within the community. This study could positively impact social change when the students work on STEM lessons to resolve various school and community issues. STEM gives students the ability to be engaged in problem solving, critical thinking, and tool use along with a variety of other skills that would equip them to have the opportunity to explore complex situations, ill-structured problems, and build prototypes (Sias et al., 2016). Students could work collaboratively to design and create something that would help the homeless in the winter or something that would help people communicate with deaf students due to mask-wearing. This impact could also become global, depending on the students' ability to "think outside the box" with the teacher's guidance.

Conclusion

This study aimed to explore elementary public school teachers' integration of technology such as digital cameras, iPads, and laptops in STEM lessons. The findings indicated that elementary public school teachers do not always integrate technological devices when teaching STEM lessons. Some teachers stated that they had not received any training in teaching STEM lessons. Some teachers had never received training on integrating various technological devices such as digital cameras, iPads, and laptops in STEM lessons. By providing this type of evidence, informed decisions concerning necessary effective professional development will help teachers who teach STEM lessons.

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Appendix: Interview Protocol

Semistructured Interview Questions for Elementary Teachers who Teach STEM Lessons

1. How many years have you been teaching?
2. Describe your teaching background.

RQ1: How do elementary school teachers utilize and integrate technology in STEM classes?

3. What is your definition of technology?
4. Describe your technology background
5. What are the different types of technology with which you are familiar?
6. Describe the types of technology you have used in STEM lessons?

SQ1a: How does the knowledge of STEM influence elementary school teachers' ability to integrate technology in STEM classes?

7. How many years have you been teaching STEM lessons?
8. Describe the STEM background knowledge you have.
9. How were you prepared/educated to teach STEM?
10. Describe what a STEM lesson looks like in your classroom.

Specific Probe: What would the students be doing?

Specific Probe: What would you be doing?

SQ1b: How does professional development regarding technology integration provide support for STEM elementary school teachers?

11. Describe a professional development you attended regarding STEM lessons.
12. Describe a professional development you attended regarding technology integration in STEM lessons.
13. How does attending professional workshops affect your classroom instruction?
14. What kind of support did you receive after attending the professional development workshop?

Interview Process

Seek permission from the Principals of the elementary schools listed on the SC Dept of Education Website	One-two weeks	Email Correspondence and Telephone calls
Contact the potential participants to determine their eligibility and willingness to participate in the study	Three weeks	Email Correspondence and Telephone calls
Supply potential participants with interview consent so that they have a better understanding of the study. Each volunteer participant who will consent to participate in the study will enter the consent form's date and signature. A detailed explanation of the study's risks and benefits will be provided, as well as a copy of the consent document. The original signed consent documents will be kept in the student records.	Two Weeks	Email Correspondence
Interviews with the ten STEM teacher	Two weeks - 50 minutes for each Zoom Interview	Email Correspondence and Zoom
A follow-up interview for clarity or additional information	Two weeks	Email Correspondence

Data Analysis: ▸ Video recording and notes will be taken during interviews. Data will be transcribed, scrutinized, coded, and analyzed to obtain categories and common themes for the report.	About three weeks.	
▸ Peer debriefing, analytic triangulation, and member checking will be involved to ensure credibility	Two weeks	
Participants will be given completed electronic transcript copies of the study to provide approval and accuracy as to whether the analyzed data is accurate.	One week	Email
Individual member checking will be done with the individual participants of the interview.	One week	Email and in-person if necessary