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# Middle School Classroom Teachers' Use of Technological Tools to Teach Scientific Inquiry

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Walden University

College of Education

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Victoria R. Gamble

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Walden University
2020

Abstract

Middle School Classroom Teachers' Use of

Technological Tools to Teach Scientific Inquiry

by

Victoria R. Gamble

MA, Lesley University, 2010

BS, University of South Carolina, 1996

Dissertation submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Educational Technology

Walden University

February 2021

Abstract

This study focused on middle school science teachers' experiences in using technological tools to teach scientific inquiry skills in the middle school science classroom. Technological tools have been increasingly used in middle schools, but knowledge is lacking as to which tools are efficient in teaching scientific inquiry skills. The purpose of this study was to gather information about the technological tools that could be adopted to make the teaching of scientific inquiry skills in middle school science classrooms more meaningful and gainful to students. The conceptual framework applied in the study was the technological, pedagogical, content knowledge (TPACK) model, as conceptualized by Mishra and Koehler in 2006. The research questions asked which strategies and tools middle school teachers use to teach scientific inquiry skills in the classroom, how confident they were when using these tools and strategies, and what positive or negative factors did they note. A qualitative, case study approach was used to collect data via purposeful sampling. NVivo software was used to analyze interviews and lesson plans from 5 middle school science teacher who used technology and taught science for at least a year. The key findings in this study indicated that middle school science teachers used authentic learning and project-based learning strategies to teach scientific inquiry skills. They used a variety of technology tools and found that some were better suited than others. The implications for research and educational practice were outlined. This study fosters social change because it is essential to the field of science education to share information that will help science teachers become efficient at selecting and using preeminent technologies to teach scientific inquiry skills in the classroom.

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APA 6

# Dedication

I dedicate this paper to my two daughters, Kayla and Autumn, and my niece, Kristen. They are my inspiration for aspiring to work harder and aim higher. I dedicate this paper to my deceased parents Charles and Lucille. I am forever grateful for their loving sacrifices and encouragement to obtain an education and change the world.

Acknowledgments

I wish to thank my family for their love and support during this process. My family is an absolute quarry of gems for their patience, and unyielding love for me, their "Forever Student." I also wish to thank my professors at Walden University for their dedication to educating scholar practitioners and preparing us for the future. I would like to thank Dr. P. and Dr. J. for their words of encouragement throughout this process. I would like to thank Mr. T. Taylor for his patience, love, and support.

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# Chapter 1: Introduction to the Study

Scientific inquiry skills have been taught in middle school science classrooms in a variety of ways (Williams, Nguyen, & Mangan, 2017). However, middle school science teachers have struggled with knowing which technological tools are efficient for teaching them (Jaipal-Jamani & Figg, 2015; Liu, Wang, Zhang, & Yan, 2017). Teachers can be successful implementing technology when they know how to use technology appropriately (McKnight et al., 2016). Thus, this qualitative case study was designed to provide data that can help science teachers select and use preeminent technologies when teaching scientific inquiry skills in the classroom. This study may foster positive social change by justifying the use of technology when scientific inquiry skills are taught in the middle school classroom.

In this chapter, I describe the literature—and the gap in the knowledge—on using technology to teach scientific inquiry skills. I state the research questions and identify and define the conceptual framework. The nature of the study is provided as well as important definitions. The assumptions, scope and delimitations, limitations, and significance of the research study are also discussed. I then summarize the main points of this chapter as I move to Chapter 2.

## Background

Various terms have been used to describe scientific inquiry in education. For example, Fraser (2017) defined scientific inquiry skills as inquiry-based teaching. Yuksel (2019) defined them as using appropriate techniques and methods to develop and nurture the science development of reasoning skills, specifically used the term *scientific reasoning skills*. Williams et al. (2017) defined these skills as process skills in science. For this study, I used the term *scientific inquiry skills*.

In addition to various terms used, scientific inquiry is being taught in various ways. The traditional hands-on approach is beginning to be replaced with technology that engages students and teaches scientific inquiry process skills (Williams et al., 2017). Twenty-first century middle school science classrooms have changed with the placement of technological tools such as desktop and laptop computers; they teach lessons with different strategies and technological activities (Lehtinen & Viiri, 2017; McKnight et al., 2016). But middle school science teachers who have used technology in the classroom have different strengths and weaknesses when using them (Minshew & Anderson, 2015). Thus, schools, school districts, and technology driven companies have offered teachers training, support, and modeling to help them sustain the use of technology (Bilici, Guzey, & Yamak, 2016). As technology training has increased, the use of technology in the middle school classroom has improved (Rutten, van der Veen, & van Joolingen, 2015). Nevertheless, there are no nationally known databases where science teachers can find information about how other teachers use technology to teach scientific inquiry skills; therefore, teachers depend on other teachers to reveal their best practices and strategies to assist each other (McKnight et al., 2016). This study was conducted to gather information about how middle school science teachers use technology in the classroom to teach scientific inquiry skills.

## Problem Statement

The problem addressed in this qualitative case study was that even though technology and technological tools are increasingly used to teach scientific inquiry skills in middle school classrooms, knowledge has been lacking as to teachers' best practices for making their teaching more meaningful. Schools have placed a variety of technological devices in classrooms for teachers to teach technology-rich lessons (Bilici et al., 2016; McKnight et al., 2016; Rutten et al., 2015). But teachers have been unsure of which technology works best to teach specific scientific inquiry skills, especially with no database on which tools that might fit the content of a lesson (Lehtinen & Viiri, 2017; McKnight et al., 2016). Thus, more information is needed about best practices (Kihoza, Zlotnikova, Bada, & Kalegele, 2016; Liu et al., 2017). To identify different technological tools and strategies for teaching scientific inquiry skills, this study gathered best practices from middle school science teachers.

## Purpose of the Study

The purpose of this qualitative case study was to gather information about the technological tools that could be adopted to make the teaching of scientific inquiry skills in middle school science classrooms more meaningful and gainful to students. Teaching with different technological tools requires teachers to have basic knowledge of technology (Kihoza et al., 2016), so can integrate new technology into their practice and make the students engage in learning (McKnight et al., 2016). The focus of this study was to discover the technological tools that have been adopted in the teaching process to make student learning more meaningful and productive.

## Research Questions

The following four research questions guided the study:

RQ1: What strategies do middle school science teachers adopt when using technology to teach science in the middle school classroom?

RQ2: What are the technological tools that middle school science teachers use to teach scientific inquiry skills, and which of these tools do teachers perceive to be more meaningful?

RQ3: Do the teachers feel that they are quite competent in their pedagogical knowledge to use the technological tools and strategies they adopt to cover the content that is used in the middle school classroom?

RQ4: What are the negative and positive factors that are related to their usage of technological tools and strategies when teaching science in the middle school classroom?

## Conceptual Framework

The conceptual framework for this case study was the technological, pedagogical, and content knowledge (TPACK) model, which was conceptualized by Mishra and Koehler in 2006. (Other frameworks considered are noted in Chapter 2 and Chapter 3.) There are three main components in this framework: content knowledge, technology knowledge and pedagogy knowledge (Koi, Chai, & Lee, 2015). Learning is the foundation to broaden knowledge, understand scientific investigation, and implement efficient teaching methods for science (Luthfia & Atun, 2018). The TPACK model can be used to improve scientific literacy skills because the model combines content knowledge, pedagogy knowledge, and technology knowledge (Luthfia & Atun, 2018).

Further, the skills needed to successfully teach technology in the classroom can be acquired with the TPACK model (Koi et al., 2015).

In this case study, I used the components of the TPACK model to explore how middle school science teachers used pedagogy to incorporate technology into their content. The components of the model were used to create interview questions that describe how well middle school science teachers adopted technology to teach scientific inquiry skills. The TPACK model was used in three ways. First, it was used to explore the teachers' content knowledge (i.e., strategies for different objectives), where the focus was on the curriculum. Second, it was used to explore the technology knowledge (i.e., technological tools incorporated into teaching practices) of the teachers, with emphasis on the type of devices used in the classroom. Third, the TPACK model was used to explore the pedagogical knowledge of the teachers, with an emphasis on the teacher's knowledge of educational strategies and guidelines that were important to the learner. The middle school teachers shared their confidence with using technology to teach scientific inquiry skills. They shared the positive and negative factors they experienced with using technology and incorporating technology into their classroom. The TPACK model is further explained in Chapter 2.

## Nature of the Study

A qualitative case study design was used for this research study. The case study design answers the *how* questions, which is a good approach when the phenomenon under study is not distinguishable from its context (Hilton, 2016; Tokmak, 2015; Williams, et al., 2017). The case study approach also involves an intensive review of one or a few subjects to understand the larger group of interest and to gain a holistic view of the research issues and problems (Krusenvik, 2016). The case study approach was used to identify the best practices that middle school science teachers used with technological tools that they adopted to teach scientific inquiry skills in middle school science classrooms. These teachers have used different technological tools to teach the different objectives of scientific inquiry skills (McKnight et at., 2016; Williams et al., 2017), but positive and negative factors have affected their ability to use technology. Other researchers have used the case study approach to document how teachers have used technology in the classroom as well as their experiences and perceptions using technology to teach scientific inquiry skills in the classroom (McKnight et al., 2016; Williams et al., 2017).

I interviewed middle school science teachers about their technology use in the classroom to teach scientific inquiry skills. The only criterion required for participating in this study was working as a middle school science teacher at the selected research site and using technology in their classroom for at least a year. The collected data were analyzed and coded to identify the resulting themes.

## Definitions

The following definitions, as found in the literature, are related to this case study.

*Case study*: A process of using in-depth questioning or examination (Williams et al., 2017). The researcher observer questioned the teacher's plan working with the students.

*Content knowledge*: An integrated form of knowledge with pedagogical knowledge and technology knowledge that together makes TPACK (Koi et al., 2015). Content knowledge is the content that teachers study specifically like Science, Math, Social Studies, or English.

*Information and communication technology (ICT)-based learning:* Twenty-first century tool used to support cognitive, metacognitive, and epistemic learning. (Koi et al., 2015). ICT- based learning is using technology to teach.

*National Science Education Standards (NSES):* A set of standards used by science teachers to teach inquiry and use technology (Weintrop et al., 2016). The NSES standards area set of national science standards used by teachers to teach science, scientific inquiry skills, and incorporate technology into the process.

*Next Generation Science Standards:* Science standards where emphasis is placed on authentic investigation in the classroom (Weintrop et al., 2016). The Next Generation Science Standards are the new science standards with an emphasis on investigating and solving problems.

*Pedagogical content knowledge:* The ability of a teacher to pedagogically adapt content to diverse student populations. (Kihoza et al., 2016). This knowledge refers to the blending of pedagogy and content knowledge together to teach students.

*Pedagogical knowledge:* An integrated form of knowledge with content knowledge and technology knowledge that together makes TPACK (Koi et al., 2015). Pedagogical knowledge is how teachers understand how to teach students.

*Process skills:* Scientific concepts such as erosion and hypothesis testing (Williams et al., 2017). Process skills were the basic scientific content that were needed to learn and understand science.

*Qualitative research:* Scientific data collected by observation and interviews (Liu et al., 2017). Video observation was used to record and observe classroom teachers.

*Substitute, augmentation, modification, and redefinition (SAMR):* A conceptual framework used to plan, assess, and evaluate technology use in the classroom (Kihoza et al., 2016). SAMR is a framework that can be used to assess the use of technology in the classroom.

*Scientific inquiry skills:* Scientific inquiry skills is the teaching of process skills in science. Teachers teach scientific concepts where students understand the targeted concepts (Williams et al., 2017). Scientific inquiry skills are the basic building blocks of learning process skills in science.

*Science, Technology, Engineering, and Math (STEM):* A practice with incorporating science with technology, engineering, and math into the classroom (Weintrop et al., 2016).

*Technology integration:* The process of incorporating technology in the classroom (McKnight, et al., 2016). Technology integration is adding technological tools into the curriculum.

*Technology knowledge:* An integrated form of knowledge with content knowledge and pedagogical knowledge that together makes TPACK (Koi et al., 2015).

Technology knowledge is how a teacher understands how to use different technological tools.

*Technological tools:* Educational technology tools such as computers, probeware, data collection and analysis software, digital microscopes, iPads, hypermedia/multimedia, student response systems, and interactive white boards (Minshew & Anderson, 2015). Technological tools are different types of technology that are used in the classroom.

*Technological, pedagogical, and content knowledge (TPACK) model:* The TPACK model is used to examine and develop teachers' knowledge of integrating technology into teaching (Koi et al., 2015). The TPACK model is a model that measures the technological, pedagogical, and content knowledge of a teacher.

*Twenty-first century classrooms:* Classrooms with nontraditional teaching tools like laptops, personal digital assistants, and digital measuring devices. (Padmavathi, 2016). The 21st-century classrooms are nontraditional classrooms that incorporate technology.

## Assumptions

This study was based on two assumptions. It was assumed that all participants were content experts and would respond honestly to the interview. It was assumed that all participants were using technology in their classroom and that their responses would be relevant to the study. Some science teachers feel that they need to be proficient with all technology, so predisposition may have affected how the participants responded in the interview. Some teachers may also prefer certain technologies over others and only shared best practices about that technology and not others.

## Scope and Delimitations

The goal of this study was to identify the best practices that middle school science teachers used with technology to teach scientific inquiry skills. The setting was two suburban middle schools in the Southeast United States. The population of interest was middle school science teachers. The study did not focus on students, administration, parents, the community, ELA teachers, math teachers, social studies teachers, or related arts teachers. The results from this study were expected to illuminate the best practices for integrating technology into the middle school science classroom to teach science inquiry skills. The results are applicable to any middle school within the United States with similar demographics.

The TPACK framework was used to gather data for the study (Young, 2016). The The SAMR framework (Gorman, 2018) was considered for this research study, but the TPACK framework (Tanak, 2018) was found to be more appropriate. More discussion on the framework is included in Chapter 2.

## Limitations

This research study was limited to self-reported data and was dependent upon volunteers to participate. Because the research study was conducted at one school district, teachers could have consulted with each other about their responses. But such consulting would influence their interview responses.

A possible bias for this study was my prior teaching experience as a science teacher. But I did not let my personal experience teaching science and using technology impact reporting the best practices as told by the sample population. To address potential personal bias, data from the participants were carefully recorded and decoded. If they elected, participants could review their interview transcripts. I triangulated the data obtained by using different data collection strategies. I also maintained a reflective journal to avoid blending my thoughts with the responses and to record accurately.

## Significance

In this qualitative study, I explored the best practices that middle school science teachers used with technological tools that can be adopted to teach scientific inquiry skills in middle school science classrooms. This study is important to the field of educational technology because it presents the most meaningful ways science teachers can use leading technologies to teach scientific inquiry skills in the classroom. I identified and codified best practices as reported by the participants. This study also yielded information to help teachers learn more about how to use technology more meaningfully. The data from this study could also contribute to the National Common Core Science Standards resources with its information on how to use different technological tools to teach scientific inquiry skills. Positive social change includes justifying the use of technology in middle school science to teach scientific inquiry skills. The use of different technological tools could prompt the school to invest in sustaining the technologies as well as in providing more training and funding for teachers.

## Summary

There are many ways for middle school science teachers to use technology in the classroom to teach scientific inquiry skills. In this chapter, I summarized the problem about the lack of research-based information regarding best practices in teaching scientific inquiry skills. I also summarized the purpose for the research study to find out about best practices in teaching scientific inquiry skills. The research literature that related to using technology to teach scientific inquiry skills was also reviewed. I identified the gap in the knowledge about using technology to teach scientific inquiry skills and stated the research questions as well as described the conceptual framework. The nature of the study was summarized and definitions pertaining to the research study were supplied. The assumptions, scope and delimitations, limitations, and significance about the research study were also identified and described.

Chapter 2 further explores the literature, the framework, and the importance of how the literature related to the research study.

# Chapter 2: Literature Review

The problem addressed in this qualitative case study was that even though technology and technological tools are increasingly used to teach scientific inquiry skills in middle school classrooms, teachers' best practices for making their teaching more meaningful are not known. Therefore, the purpose of this case study was to gather information about the technological tools that could be adopted to make the teaching of scientific inquiry skills in middle school science classrooms more meaningful and gainful to students.

The literature revealed that teachers have different perceptions about the various technological tools used to teach scientific inquiry skills in the middle school science classroom. In a qualitative case study, Williams et al. (2017) investigated how a science teacher used technology to teach scientific inquiry skills in the middle school classroom. Williams et al. (2017) reported that the teacher used innovative technological techniques to engage students with the curriculum. In another qualitative case study, McKnight et al. (2016) measured the technology proficiency of science teachers and found that most reported having proficient or advanced skills with using technology in the middle school classroom. McKnight et al. concluded that science teachers have a wealth of knowledge, skills, and technological strategies that could convert the science classroom into a technology learning environment.

The National Science Education Standards (NSES) is a set of standards used by science teachers to teach scientific inquiry skills and use technology (Weintrop et al., 2016). The NSES standards mandate that science teachers incorporate technology into the curriculum to teach scientific inquiry skills, but there are no known national sources that stipulate which technological tools are progressively used to teach science inquiry in these classrooms (Padmavathi, 2016). Gathering information from middle school science teachers who used technological tools to teach scientific inquiry skills in middle school science classrooms could help develop a resource of best practices that could be shared.

In this chapter, I list the sources cited in this literature review and how the sources provide evidence for the central research questions recommended in this qualitative case study. I describe the literature search strategies used, the conceptual framework and how it has been used in recent studies, and literature related to key concepts of this study. I summarize the major themes of the literature: technology in teacher preparation, middle school and technology, scientific inquiry skills, and educational technology and provide provisional material to connect the gap in the literature.

## Literature Search Strategy

While searching the literature for this study, the Walden University's Library search engine, Google Scholar, ResearchGate, and ERIC- Institute of Education Sciences were used to find articles relating to teaching science in the middle school classroom with technology. The following keywords were used: *science inquiry + teaching + strategies, TPACK, TPACK Model + science classroom, scientific inquiry skills + middle school classroom,* and *efficient teaching practices + TPACK Model*. A search for *best science teaching practices with technology, and teaching science inquiry with technology* was also conducted.

A search for scientific inquiry skills in the middle school classroom was conducted with the following databases: Dissertations & Theses @ Walden University, ERIC, GALE Virtual Reference Library, IBISWorld, IEEE Xplore Digital Library, LearnTechLib-The Learning and Technology Library, National Science Foundation NCES Publications, and ProQuest Central. While the search yielded many articles about scientific inquiry skills, they did not focus on middle school classrooms. Another search was warranted with the words *science* and *inquiry* to find better results and narrow the list. The new search provided more success using the Boolean term and yielded a more streamlined list of articles.

In Google Scholar, ResearchGate, and ERIC, a search was conducted for *TPACK* and *TPACK model in the science classroom*. The date range was customized for articles within the last 5 years. The search yielded over 10 pages of articles, websites, books, and mentions about the TPACK Model. On each page was 20 listings. The search was repeated following the same search criteria with the additional use of a Boolean term. The returned list was smaller and yielded more articles that related to this research study. There were many articles with PDF files and the PDF file articles were more accessible. Some articles required that the author be contacted for permission to use the article in the research study. All of the authors that were contacted responded positively and gave permission to use their research.

## Conceptual Framework

The TPACK Model is a framework which identified the knowledge that was needed to successfully teach technology in the classroom (Mishra & Koehler, 2006). The

TPACK Model is used to identify best practices adopted by middle school science teachers to teach scientific inquiry skills. The model was introduced by Mishra and Koehler of Michigan State University in 2006. Mishra and Koehler (2006) identified three different types of knowledge: Content Knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) to implement technology in the classroom (Mishra & Koehler, 2006).

Mishra and Koehler's research into developing the TPACK theory was based on the Substitution, Augmentation, Modification, and Redefinition (SAMR) model (Portnoy, 2018) which had four distinct categories: Substitution, Augmentation, Modification, and Redefinition to incorporate technology into the classroom (Kihoza et al., 2016). The SAMR model was used mainly to evaluate technology usage in the classroom and not as a teaching device (Kihoza et al., 2016). Portnoy (2018), wrote that the SAMR model redefined the way that technology impacted the classroom and the nature of instruction, therefore the SAMR model was a great platform for the TPACK theory to be based upon. While the SAMR model was used more to evaluate, the TPACK model relied on the connections between technological knowledge, pedagogical knowledge and content knowledge and was used to support teachers in their pursuit of integrating technology into their lessons (Kihoza et al., 2016).

The TPACK model was used in Guzey and Roehrig's (2009) qualitative research study which explored how teachers used the TPACK model to teach with different technology in the classroom. The TPACK model analysis revealed that some teachers considered themselves proficient, blending pedagogy with technology, while other teachers struggled with incorporating them (Guzey & Roehrig, 2009). In 2010, Allan, Erickson, Brookhouse, and Johnson applied the TPACK model to their qualitative research study where they launched The Maine Laptop Program. Middle school students across the state were given laptops and teachers were given professional development training to integrate technology into their curriculum. The TPACK model analysis revealed that over a period of three years, there was a significant increase in technology skills; an increase in content knowledge and scientific inquiry skills; and positive transformations with pedagogy for teachers (Allan et al., 2010).

Jang and Tsai (2013) used the TPACK model in their quantitative research study to investigate how secondary science teachers were influenced by gender and teaching experience. Jang and Tsai surveyed 1293 teachers and after analyzing their responses found that female teachers had more content and pedagogical knowledge and that male teachers had a higher technological knowledge (Jang & Tsai, 2013). More male teachers were using technology to teach science. After further analysis, they also found that content knowledge and pedagogy knowledge was more established with experienced science teachers, therefore teaching experience influenced how technology was used in the classroom (Jang & Tsai, 2013).

Rosenberg and Koehler (2015) defined TPACK as the description of information used to clarify certain content with technology while Bang and Luft (2013) defined the TPACK framework as a system used to identify technological knowledge, content knowledge, and pedagogy knowledge of teachers. In Bang and Luft’s (2013) qualitative research study, they used the TPACK framework to identify strategies that teachers used to incorporate technology into their classroom to teach science inquiry skills. Bang and Luft, 2013 stated that in order for the TPACK framework to be successfully implemented, teachers must create ICT 21st century learning communities within their school and establish workable relationships with each other to build a foundation of trust to work together to teach scientific inquiry skills with technology. The TPACK framework can be used to teach The Next Generation Science Standards placing emphasis on authentic scientific investigation in the classroom. (Weintrop et al., 2016).

There were several research studies which provided evidence for how ICT 21st century learning communities and TPACK had impacted education (Baran, Bilici, Sari, & Tondeur, 2017; Bilici et al., 2016; Finger et al., 2015; Koi et al., 2015). The research studies spanned a variety of years and education platforms and yielded data and results that supported the use of the TPACK framework in teaching. Koi et al.'s (2015) meta-analysis qualitative research study reviewed seven published theoretical research papers about how teachers used the TPACK framework for instructional planning and e-learning. The research study concentrated on how TPACK could support pedagogical efforts to teach students and support 21st century competencies. Data analysis revealed positive results with technology incorporation in the classroom. Padmavathi's (2016) meta-analysis research study presented findings from several previous research studies involving the TPACK framework as a tool that taught teachers how to incorporate technology into their lessons. The importance of educational technology in the classroom was identified and the TPACK framework was used to successfully help prepare teachers on how to apply different technology tools in their classroom (Padmavathi, 2016).

PK was necessary for establishing a foundation for teaching (Baran et al., 2017; Finger et al., 2015; Martin, 2015; Tokmak, 2015). PK consisted of information about how to teach and the history of education and teachers needed to know strategies and develop skills about how to teach students. CK was knowledge about the content or subject and teachers were expected to be experts in their respective field of study (Finger et al., 2015; Martin, 2015; Tanak, 2018; Tokmak, 2015). TK was knowing how to incorporate technology in the classroom. Technology integration in the 21st-century classroom was on-going, and teachers were expected to use technology to teach (Bilici et al., 2016).

The research questions of this qualitative research study focus on how teachers used technology in their classrooms, how they apply pedagogy to teach students, and how content is taught with the aid of technology, therefore the TPACK framework was appropriate. The TPACK framework is important to this qualitative research study because I will be able to describe the pedagogy, content, and technology knowledge of teachers as they discuss the best practices, they adopt to integrate technology into their classroom.

## Literature Review Related to Key Concepts

A review of the literature related to technology use in the science classroom revealed four themes. In this section I discuss literature for the following:

- Technology in teacher preparation (Bilici et al., 2016; Finger et al., 2015; Pöntinen, Dillon, & Väisänen, 2017)
- Middle school and technology (Bippert, 2019; Hilton, 2016; Minshew & Anderson, 2015)

- Scientific inquiry skills (Castle & Ferreira, 2015; Fraser, 2017; Williams et al., 2017) and
- Educational technology (Chun, Kern, & Smith, 2016; Garba,Yusuf, & Busthami, 2015; McKnight et al., 2016).

**Technology in Teacher Preparation**

Teacher preparation programs added technology as a part of their curriculum to help prepare preservice teachers for the classroom. Technology classes were added to many teacher education programs at colleges and universities as a requirement for graduation (Baran et al., 2017). The explosion of technology within the last decade helped to guide the pedagogical, content, and technology knowledge of teacher education programs (Baran et al., 2017; Tanak, 2018; Tokmak, 2015).

In a meta-analysis study about technology, Martin (2015) examined how teacher education programs prepared preservice teachers to teach with innovative technologies. Martin (2015) reported that the assimilation of technology into daily life would spread into education and impact schools and education preparation programs and that there was a need to reform teaching and learning. The International Society for Technology in Education created a set of standards to normalize how educators integrated and taught technology in the classroom (Martin, 2015). The new standards emphasized the teacher as the architect of knowledge construction while helping the student to build upon their technology knowledge. Martin (2015) introduced content, pedagogy, and technology knowledge as the overall assessment that researchers used to assess tactics for successful technology integration. Martin (2015) reviewed how content, pedagogy, and technology knowledge was used to build technology confidence and provide learning opportunities for teachers through technology modeling. For preservice teachers, the benefits of observing technology-rich environments would increase their knowledge in all areas of the technology standards (Martin, 2015). Martin's (2015) research compared the different instructional practices for preservice teacher training. The National Educational Technology Standards for Teachers was created to provide support and communicate goals for teacher education curriculum and articulate the objectives for successful technology implementation (Martin, 2015). In 2006, all teacher training programs in the United States provided instruction on technology integration (Martin, 2015). Technology was placed in content-specific coursework to expand the confidence of preservice teachers while preparing them to use the technology as an in-service teacher. Martin (2015) suggested that content, pedagogy, and technology knowledge was the catalyst for designing the coursework. Technology knowledge was more prominent in education programs, and professional development activities (Martin, 2015). School faculty also collaborated with in-service school teachers to develop technology-infused curriculum that helped preservice teachers with content, pedagogy, and technology knowledge (Martin, 2015).

In two other research studies about using technology in the classroom, Finger et al. (2015) reviewed the development of teacher education programs in Australia to use technologies to assist with teaching and Tokmak (2015) investigated technology use in teacher preparation of early childhood education preservice teachers in Turkey. In Finger et al.'s (2015) quantitative research study the government funded a five months long project called Teaching Teachers for the Future Project at institutions of higher education throughout the country (Finger et al., 2015). The research study was conducted at 48 different institutions across the country with 37 of them being public institutions. Finger et al. (2015) reported that the Australian government believed that the quality of teacher education needed to be upgraded to increase productivity in the country and the importance of developing a program with content, pedagogy, and technology knowledge was critical to the success of the country. The purpose was to use content, pedagogy, and technology knowledge to prepare preservice teachers for the classroom. Participants received a pre- and post-survey online via their school email. Finger et al.'s (2015) findings revealed that more participants showed teacher confidence with using technology skills. Students had an improved confidence in using ICT, but there was room for improvement (Finger et al., 2015). In Tokmak's (2015) qualitative research study teachers were asked to design an educational computer game with PowerPoint. The preservice teachers selected were in the same Early Childhood Education course and had knowledge of educational computer games. There was a total of 21 participants with two being male (Tokmak, 2015). Tokmak (2015) used three instruments to collect data interviews: a demographic questionnaire, interviews, and journals. Tokmak (2015) revealed that that most of the participants were content with their game they designed because their games were designed with the classroom environment in mind. The preservice teachers used content, pedagogy, and technology together to create a game where students were able to learn, thereby presenting success for the technology assimilation in their teacher preparation program (Tokmak, 2015).

Bilici et al.'s (2016) qualitative research study assessed the content, pedagogy, and technology knowledge of preservice teachers over a semester long course. Bilici et al. (2016) discussed the importance of integrating technology into teaching. The twenty-first century classroom had become laden with technology and teachers were expected to use technology to teach (Bilici et al., 2016). Bilici et al. (2016) sought to show how content, pedagogy, and technology knowledge were unique and would benefit teacher preparation programs. The research study had a sample group of 27 preservice science teachers from a university in Turkey who offered to join in the case study (Bilici et al., 2016). Data were collected through lesson plans and observations over a period of thirteen weeks. There was a significant increase in the use of technology in the classroom, but no opportunities for support (Bilici et al., 2016). Bilici et al. (2016) concluded that it was critical to identify and measure a teacher's use of technology in the classroom to foster efficient integration of technology into their future teaching.

Like Bilici et al.'s (2016) qualitative research study, Tanak's (2018) mixed-methods research study also addressed the integration of technology into classroom using content, pedagogy, and technology knowledge for preservice teachers. The ability of teachers to incorporate technology into the classroom was an essential part of teacher education (Tanak, 2018). Tanak (2018) evaluated how a course in a teacher preparation program develop the content, pedagogy, and technology knowledge of preservice science teachers. The sample population was 15 preservice teachers, 3 males, and 12 females enrolled in a 2-year Master of teaching program at a public university (Tanak, 2018). The students completed a content, pedagogy, and technology knowledge questionnaire and submitted science lesson plans using technology for analysis. Tanak (2018) discovered that the teachers used technology mostly as a teaching tool to support instruction. They used content knowledge more, and used pedagogy knowledge less (Tanak, 2018). Tanak (2018) concluded that the focus of teacher preparation programs should be on understanding how to blend technology, content, and pedagogy knowledge together.

Baran et al.'s (2017) quantitative research study and Pöntinen et al.'s, (2017) research study both examined preservice teachers' and technology integration in the classroom. Teacher preparation programs had added the practice of preparing preservice teachers how to teach technology. Baran et al. (2017) sampled 215 preservice teachers from three universities in Turkey over one semester. The preservice teachers were given the synthesis of qualitative evidence (SQD) scale, which was developed by Tondeur, Van Braak, Ertmer, and Ottenbreit-Leftwich in 2016. The scale rated the teachers on the efficiency of the strategies they learned while preparing to integrate technology in their future classrooms (Baran et al., 2017). Baran et al. reported that the most commonly used strategies for technology integration were reflection and modeling. There were limited opportunities to offer feedback and evaluation for preservice teachers. Baran et al. concluded that teacher education programs that implemented technology integration practices would benefit preservice teachers as long as there were ways to offer feedback for improvement. Pöntinen et al.'s (2017) studied technology education programs for preservice teachers and revealed that teacher preparation programs taught pedagogical knowledge about technology education in the classroom but failed to offer practice and support for students enrolled in the program. Students were not given the opportunity to turn their analytical knowledge into practical knowledge, thus they struggled with incorporating technology later in their professional careers (Pöntinen et al., 2017). Pöntinen et al. (2017) reported once the preservice teacher was in a classroom, support for technology was not guaranteed. Teacher preparation programs revealed that when support was offered for technology, preservice teachers were expected to use technology in the classroom (Pöntinen et al., 2017).

Another research study that focused on technology in the classroom was Foulgeri, Graziano, Schmidt-Crawford, and Slykhuis's (2017) mixed-methods research study that investigated how Teacher Education Technology Competencies (TETC) supported teacher candidates as they prepared to become teachers who use technology frequently. Foulgeri et al. (2017) reported that collaborative research approaches were used to assist with developing the TETCs. The research approaches were the efforts of technology-related information, a Delphi method for professional feedback, and an open call for public remark (Foulgeri et al., 2017). Foulgeri et al. (2017) reported that most teacher preparation programs were semester long and used a separate technology integration course to learn how to teach with technology. TETCs placed teacher candidates with experienced teachers in classrooms along with the technology integration course. Foulgeri et al. (2017) reported that crowdsourcing, where many individuals could participate, addressed the aptitudes needed by teacher to support the development of preservice teachers as they acquire knowledge to teach with technology. The Delphi method validated and refined ideas about TETCs through survey-driven data collection. Public comments yielded positive, enthusiastic attitudes towards the TETCs (Foulgeri et al., 2017). Foulgeri et al. (2017) concluded that TETCs were positive and all teacher candidates should have equitable, high-quality technology experiences throughout their teacher preparation programs based upon a set of competencies that were used to help guide teacher educators in understanding what was needed to integrate technology.

**Middle School and Technology**

Technology integration in middle school classrooms encompassed a variety of tools. Minshew and Anderson's (2015) qualitative research study discussed the use of how to use technology with one-to-one iPad use in the science and math classroom. Minshew and Anderson focused on two sample groups, students at the middle school level and middle school teachers in the classroom. They selected a Title I middle school in the southeastern part of the United States and used pseudonyms for the school and participants (Minshew & Anderson, 2015). The student group was diverse with a total of 647 participants (Minshew & Anderson, 2015). Minshew and Anderson only sampled the $6^{th}$ grade teachers because their ratio of students to teachers was 100 to 4. Out of the $6^{th}$ grade teachers, all choose to participate and two were selected for a case study (Minshew & Anderson, 2015). Data were collected via interviews, observations, circle of influence diagram, field notes, lesson plans, and video data (Minshew & Anderson, 2015). The data were coded, and the researchers saw that teachers felt good about the use of one-to-one technologies (Minshew & Anderson, 2015). The benefits of one-to-one technologies were creativity with student learning, application of critical thinking skills, collaboration, and digital literacy (Minshew & Anderson, 2015). Minshew and Anderson's research also revealed how iPad use gave teachers the ability to include technology-rich lessons that advanced student learning and engaged students in the learning process. The data also identified some barriers, teacher bias within their own struggle with technology, connectivity, and professional development. Teachers who used one-to-one technologies were more creative with student learning to apply critical thinking skills, collaboration, and digital literacy (Minshew & Anderson, 2015). iPad use in the classroom advanced student learning and engaged students in the learning process (Minshew & Anderson, 2015). Integrating technology in middle school classrooms was superb, but a framework was needed to assess how efficient it was for middle school teachers.

Like Minshew and Anderson (2015), Hilton's (2016) qualitative case study also used technology integration into the classroom and two separate models were used as two ways integration could happen in the classroom. Hilton examined the use of each model in the classroom. Hilton's research study was conducted in an urban school district in southwestern Pennsylvania. The case study followed two 8$^{th}$ grade middle school social studies teachers use of 30 iPads to teach content to their students (Hilton, 2016). The teachers had two separate technology models to use. Each teacher used one model for half of the school year and then the other model for the other half (Hilton, 2016). The findings suggested that the first model did not function in a hierarchical manner (Hilton, 2016). There was no scaffolding because each area was considered a different task, therefore when one model was completed, the teacher moved to the other. The second model gave the teachers a way to scaffold and build within the lessons (Hilton, 2016). Hilton (2016) reported that the teachers agreed that the models were both useful, but the second model appeared more easily aligned with teacher-centered instructional design philosophies and focused on the teacher (Hilton, 2016).

Young (2016) conducted a meta-analysis of a technology framework in mathematics education to show how technology-enhanced lessons can be efficient in the mathematics classrooms. Young reported the framework was used because it provided practical, empirical and theoretical considerations for the integration of technology in the math classroom. Young chose a meta-analysis to identify specific variables that can account for variation on the efficiency of technology integration in the mathematics classroom. Young found that the technologies that were integrated in the mathematics classroom focused on the functionality of the tool and how the tool could be used to improve and enhance mathematics. The framework was provided as a valid and reliable framework to guide the investigation and the study supported the use of the framework as an analytical tool characterized by pedagogical and content knowledge in the mathematics classroom (Young, 2016).

Romine, Sadler, and Wulff (2017) used a mixed methods study to explore middle school gender differences related to science and technology. Romine et al. developed the Measure of Affect in Science and Technology to measure middle school students' perspective about science and technology. Romine et al.'s methodology focused on the how the students felt about science and technology. Romine et al. monitored the student's perspectives but found that they did not understand fully. Therefore, they developed and implemented a study instrument to fill this gap (Romine et al., 2017). This instrument, the Measure of Affect in Science and Technology (MAST), assessed how students were interested in science and technology (Romine et al., 2017). A classical test theory and Rasch analysis was used to produce dependable and acceptable explanations regarding middle school students' affect and propose recommendations for its use (Romine et al., 2017). Romine et al. sampled 79 6$^{th}$ graders at a middle school in a small Midwestern city with 45 were male and 28 were female students. Romine et al. reported that after the preliminary evaluation of construct validity using classical test methods, they added three items to the assessment, and administered the updated survey to a total of 138 students. There were 92 6th graders and 46 7th graders. The student population equated to 79 female, and 59 male students (Romine et al., 2017). Romine et al. found that there was a high interest in science careers because science and technology carried the highest affective score. Romine et al. (2017) reported that males exhibited greater aptitudes of personal interest in science, science careers, and the biggest interest in technology. Romine et al. concluded that middle school students learned more in science with technology use.

Tyler-Wood, Cockerham, and Johnson's (2018) quantitative research study examined how teachers and students used technology in a rural middle school and Bippert's (2019) qualitative case study analyzed the interactions of students and staff members as they used technology at school. Even though the sample populations were different, both research studies analyzed the integration of technology in the middle school classroom. Tyler-Wood et al. (2018) reported that according to the Next Generation Science Standards all students needed to attain a vigorous K-12 science education to be prosperous globally and that this goal can be achieved when teachers and students were required to use technology. Tyler-Wood et al. believed that technology-integrated instruction could convert contemporary classrooms to promote scholar enthusiasm, longer attention spans, and academic success by sharing new methods of learning with the scholar. Tyler-Wood et al. noted that this transformation begun with training teachers to use technology in the classroom and with teaching them how to best apply the technology to help students. Tyler-Wood et al. sampled 24 teachers and a group of seventh grade students in two rural Texas school districts. The schools were selected based on demographics where 70% of students were White, 23% were Hispanic, and 3% were Black (Tyler-Wood et al., 2018). The remaining percentage of students were Native American, Asian, or biracial (Tyler-Wood et al., 2018). Tyler-Wood et al. (2018) stated that teachers and students received online pre- and post-intervention surveys. The students received The International Association for the Evaluation of Educational Achievement's assessment known as TIMSS and the teachers received the Concerns-based Adoption Model-Levels of Use (Tyler-Wood et al., 2018). The pre- and post-surveys were assessed, and the data were analyzed using one-way Analysis of Variance (Tyler-Wood et al., 2018). Tyler-Wood et al. concluded that using technology did not preclude a teacher's or student's successful with technologies. Success was accomplished with substantial planning, student training, and teacher training in order to incorporate technology in the middle school classroom.

Bippert (2019) sought to capture the cultural perceptions related to technological tools using a computer-aided reading intervention program. Bippert reported a trend with technology-based comprehension intervention programs at middle schools in the United

States and these programs were promoted as interesting and great for students, but there was a lack of consistent evidence to support that claim. Bippert sampled two teachers, four students, and two administrators all at the same urban middle school. Bippert analyzed the perceptions of each group as they used the reading intervention program. Data were collected through observational field notes, screen and audio recordings, interviews, and informal conversations. Bippert's findings showed that the participants' opinions of the reading tactics and technology tools differed across participant groups. The perceptions about technology differed among teachers, students, and administrators in regard to the reading intervention program (Bippert, 2019). Students felt the program did not differentiate enough for their unique reading difficulty. Teachers felt the program was a great resource, but additional support was needed. Administrators felt the program was worth the funding because it was marketed as a top technological tool to help struggling readers (Bippert, 2019). Bippert concluded that schools should focus on their individual and technology resources to know what was meaningful to foster achievement and include a choice of comprehension strategies to support active commitment, opportunities for social activities and technology integration.

**Scientific Inquiry Skills**

Scientific inquiry skills were taught as a separate science concept in middle school classrooms worldwide (Williams et al., 2017). A comparison of the same class over a two-year time revealed how one science teacher used a variety of technology to teach scientific inquiry skills. Williams et al. (2017) collected the teacher's technology integration data to teach science inquiry skills in the classroom. The teacher was a nineyear veteran teacher that taught middle school science at a New Zealand high school. The data collected revealed that the teacher scaffolded the lessons with technology for over two years with the same group of students (Williams et al., 2017). Science inquiry skills were taught as a scaffolding concept to increase student engagement and interest in science (Williams et al., 2017). Students explored authentic science problems and real-world applications with the addition of technology in science. Each year the students' knowledge and understanding of science inquiry skills increased with the use of technology (Williams et al., 2017). There was value in using different technologies in the classroom because some students gravitated more towards one or more technological tools and gained an advantage to understand and process the scientific inquiry skills objective (Williams et al., 2017). Science inquiry as a separate concept was efficient.

The concept of scientific inquiry skills has also been integrated with the TPACK framework to teach the concept (Jaipal-Jamani & Figg, 2015). The Professional Learning Design Model (TPLDM) along with the components of the TPACK framework, were used to teach technology-enhanced lessons in the science classroom (Jaipal-Jamani & Figg, 2015). Jaipal-Jamani & Figg's (2015) case study approach studied how blogging could be used to understand science inquiry. This research study was conducted at an inner-city school over 4 weeks with three female eighth grade middle school science teachers who had limited experience using blogs for classroom instruction (Jaipal-Jamani & Figg, 2015). The teachers attended a technology professional development workshop to learn how to implement technology-enhanced lessons to teach eighth grade science objectives (Jaipal-Jamani & Figg, 2015). Jaipal-Jamani & Figg (2015) concluded that

PCK increased to decipher teaching strategies and content for efficient science teaching. TK increased for efficient instruction with technological tools in the science classroom (Jaipal-Jamani & Figg, 2015). Attendance at professional development workshops increased CK and TK (Jaipal-Jamani & Figg, 2015). Blogging in science education helped endorse 21st Century learning skills and increased the TPACK of students and teachers (Jaipal-Jamani & Figg, 2015). Furthermore, Jaipal-Jamani & Figg stated professional development added value to the science curriculum for teachers, and the technology workshops helped teachers execute lessons successfully (p. 26).

In the United States, science inquiry skills combined within a framework was the key to a good science program (Castle & Ferreira, 2015). In China, a good science program was the technology knowledge was used to help improve science education and add technology into the classroom (Liu et al., 2017). In Thailand, the art of good teaching and learning practice was developed through scientific experimental skills using inquiry-based learning with digital technology (Thanapud, Kamyod, Chaisricharoen, & Yooyatiwong, 2018).

The teaching structure in China was categorized into teacher-centered and teacher-led instruction (Liu et al., 2017). Liu et al.'s qualitative research study used video observation to analyze the use of technology in six classrooms in the Jilin Provence D of China (p. 15). The video was encoded, and information was entered into tables to analyze the data (Liu et al., 2017). The TPACK structure of teachers' relationships, and teaching styles enhanced the fluency of classroom teaching and technology used to teach science

(Liu et al., 2017). The TPACK structure helped improve science education in China and integrated technology into the classroom (Liu et al., 2017).

In Thailand, digital technology was used to create a learning management system to promote inquiry-based learning (Thanapud et al., 2018). Thanapud et al.'s (2018) research study was conducted in Chiang Rai, Thailand, with eighth grade science learners to observe behavior while using digital technology in the science classroom. Student learners enjoyed using digital technology to complete scientific experiments (Thanapud et al., 2018) and teacher confidence with using digital technology increased due to daily classroom use (Thanapud et al., 2018).

Castle and Ferreira (2015) reported that in the United States, The National Research Council released a document which reviewed the need to ask scientific questions, develop models and simulation, and prepare and carry out investigations, The Next Generation Science Standards (p. 14). The requirement for teaching science needed to be more than just content and assessments (Castle & Ferreira, 2015). A qualitative research study at a middle school in southeastern Michigan selected 12 science teachers to participate in a 5-Point Likert survey that questioned the teachers' overall knowledge about teaching middle school science (Castle & Ferreira, 2015). In addition to the survey, a focus group session and observations occurred (Castle & Ferreira, 2015). In the focus group, the teachers were interviewed about their obligations to teach and apply the Next Generation Science Standards (Castle & Ferreira, 2015). All teachers enjoyed using a guided inquiry approach to teaching because the students investigated and asked questions (Castle & Ferreira, 2015). A structured inquiry was also preferred for teaching scientific inquiry skills because the teacher asked questions, and the students supplied the correct answer (Castle & Ferreira, 2015). An open-ended inquiry was least favored because the answer to the question was inconclusive (Castle & Ferreira, 2015). This study indicated that teachers have a decent understanding of scientific inquiry skills concepts but realized that a framework was needed to teach additional skillsets like scientific reasoning and theory development (Castle & Ferreira, 2015).

Specific components of the TPACK framework were used to problem solve with science teachers (Fraser, 2017). Pedagogical Content Knowledge (PCK) was introduced to science teachers to discover how optimal learning could take place in a mostly traditional distance learning environment (Fraser, 2017). The distance education learning environment was paper saturated and deprived science teachers of hands-on science-oriented practice (Fraser, 2017). Fraser stated interviews conducted with the four science professionals lasted for 45 minutes concerning their capabilities with instructional design application and implementation in distance education. The four science professionals stated that the design application was not optimal for learning scientific inquiry skills (Fraser, 2017). The paper-based tutorials were best for sharing practices but failed to engage the learners in communities of hands-on scientific inquiry skills (Fraser, 2017). The focus of the Distance Education program was not centered on the development of strategies for scientific inquiry skills practice (Fraser, 2017).

Scientific inquiry skills practice happened at a young age. Aydemir, Ugras, Cambay, and Kilic’s (2017) quantitative research study examined the how preschool teachers view science and scientific inquiry skills. Early science and scientific inquiry skills exposure led to the development of positive attitudes with science. (Aydemir et al., 2017). Scientific inquiry skills were expressed as understanding the natural world and understanding evidence that support natural phenomena (Aydemir et al., 2017). Scientific inquiry skills were also conveyed as the accomplishments of learners scientific as they understand the natural world (Aydemir et al., 2017). In this research study at Firat University, Turkey, preservice preschool science teachers were given a questionnaire to collect their perception about scientific inquiry skills (Aydemir et al., 2017). The overall opinionated data concluded that the nature of science and scientific inquiry skills should be taught at a young age (Aydemir et al., 2017). The preservice preschool teachers recommended that education courses use appropriate pedagogical approaches to teach the core fundamentals of the nature of science and scientific inquiry skills in undergraduate education to preservice teachers (Aydemir et al., 2017). Ayedemir et al. concluded that the teachers believed teaching scientific inquiry skills at a young age helped prepare young learners to understand science and scientific inquiry skills better as they progressed.

**Educational Technology**

Educational technology was a concept enhanced technology integration in the classroom (McKnight et al., 2016). McKnight et al.'s (2016) mixed methods research study sampled 44 teachers to discover how technology-enhanced student learning. Teachers completed a voluntary online survey about their technology use, and 40 out of the 44 teachers responded (McKnight et al., 2016). The findings conveyed most teachers reported proficiency or advanced skills with technology use. Few teachers described issues with incorporating technology in the classroom; instead, there was a high level of commitment to using technology in the classroom to enhance learning (McKnight et al., 2016). Yet, there were a few barriers that hindered successful implementation: lack of administrative support, insufficient training, and lack of support to sustain technology usage in the classroom. Despite the barriers, educational technology was efficaciously integrated in the classroom (McKnight et al., 2016).

McKnight et al. (2016) reported that teachers were advanced with technology integration. Pilgrim and Martinez's (2015) qualitative research study examined how teachers integrated technology and web literacy skills to develop literacy skills (Pilgrim & Martinez, 2015). Pilgrim and Martinez (2015) wrote The United States Department of Education released the National Technology Plan in 2010 and the purpose of the plan was to introduce 21st century literacy skills into the classroom because literacy was no longer traditional with books, paper, and pencils. The impact of technology perception affected teacher's web literacy skills, technology integration, and TPACK. Teachers communicated a lack of confidence with incorporating web literacy skills and suggested that web literacy skills be taught in the classroom regardless of the content (Pilgrim & Martinez, 2015). Teachers indicated the lack of an evaluation method to distinguish between credible and noncredible sources on the web hindered how to distinguish between the two types of sources (Pilgrim & Martinez, 2015).

Technology integration was used to examine the use of TPACK to teach STEM in middle school classrooms (Rahman, Krishnan, & Kapila, 2017) Robotics technology was the concept for teaching STEM education. A group of twenty teachers from an urban inner-city middle school with a familiarity using robots and a robotics-based instructional framework in their classroom were invited to participate. (Rahman et al., 2017). Observations and a questionnaire were completed illuminating how the teachers used robotics-based technology and the TPACK model was applied to the robotics-based instructional framework. First, Technological Knowledge was required to teach robotics-based technology. The teacher handled issues that arose and modeled the use of the robotic equipment (Rahman et al., 2017). Second, Pedagogical Knowledge was required by teachers to differentiate, scaffold, and group students. Last, Content Knowledge was needed because teachers had to know their grade level specific curriculum to teach the correct information (Rahman et al., 2017). The TPACK model was essential to the success of the program.

In another STEM program in the United States, teaching portfolios were introduced through the Engineering for All program, a 5 year-long STEM program that was supposed to develop middle school technology and highlight the duties of engineers in solving global and community-based design (Lomask, Crismond, & Hacker, 2018). Twenty-two teachers were tasked to teach the engineering units over time to middle school students. Lomask et al. collected data with a 5-point Likert scale and the submission of teaching portfolio logs yielded results that most teachers had encouraging views about the new technology curriculum (Lomask et al., 2018). The use of technology was beneficial in teaching the engineering theme and classroom instruction, but the content of the unit was too hard to accurately understand (Lomask et al., 2018).

In more science programs, Khlaif, Gok, and Kouraïchi (2019) examined how instructional practices in technology education in Palestine was used to identify the importance of procedures to teach educational technology and Chun et al., (2016) examined how instructional practices in a meta-analysis research study focused on the teaching language with technology in the classroom. Middle school teachers examined the procedures and processes used to design technology-enhanced activities for a one-to-one mobile technology environment in a middle school environment (Khlaif et al., 2019). Khlaif et al. used a multiple-case study design with 27 teachers who volunteered for the research study from different middle schools in the technology restricted country. The volunteer teachers attempted to use collaborative procedures to plan technology-rich lessons. Data were collected through observations, organized interviews, and focus groups every month for 8 months with interviews scheduled at the convenience of the participants and completed within 30 minutes (Khlaif et al., 2019). The results presented that the violence in the region affected how the design teams worked together (Khlaif et al., 2019). Furthermore, the social and religious factors delayed the discussion of the group due to disagreeing policies from the Ministry of Education (Khlaif et al., 2019). Time, culture, and security barriers were the main challenges for the design teams as they attempted to meet and design their activities (Khlaif et al., 2019). Despite their best efforts, instructional practice procedures were difficult to maintain as intrusive sources delayed or deterred progress.

Technology changed and had evolved but the concept of language acquisition did not change and was a needed concept in education (Chun et al., 2016). The dilemma for some teachers was how to incorporate technology into teaching practices to best teach language (Chun et al., 2016). Speech could be taught using digital technologies. Digital devices were physical devices that could be manipulated to produce sound and video (Chun et al., 2016). Virtual environments were available for users to practice language use and re-create themselves to interact with others (Chun et al., 2016). Purposeful use of technology engaged the learner and teacher to indicate meaningful learning, critical reflection, and focus on what was important, and using the right technology could influence how well language was acquired and retained (Chun et al., 2016). Technological tools increased success with instructional practices.

Educational technology was used to shape the foundation of 21$^{st}$ century classrooms (Garba et al., 2015) and was also influenced by pedagogy (Tondeur et al., (2016). The use of 21$^{st}$ century technology-based teaching methods for instructors in Malaysia and the Asia Pacific showed how infrastructure and internet connectivity provided students and instructors with the chance of embracing 21st century teaching-learning methods that certified the development of 21st century technology skills like sending an email, uploading a document, and connecting to the internet (Garba et al., 2015). The availability of internet connectivity was a key component for a transfer from content-based learning to interactive project-based learning. Eight teachers from two non-urban schools in the state of Kedah in Malaysia were selected for the research study. Garba et al. collected and analyzed data and revealed a distinctive organization in the use of computer and internet among teachers. Even with the advances of internet and 21$^{st}$ century technologies, the method to teaching and learning did not alter (Garba et al., 2015). Teachers in Malaysia had simple training on the use of computers and using the internet by attending conferences and taking courses. However, Garba et al. reported teaching and learning had centered around the use of current and evolving technologies. Teachers were not comfortable using emerging technologies (Garba et al., 2015). Teachers and technology were the critical factors in a 21st century classroom. When teachers adopted the use of 21st century learning approaches and teaching methods, classroom practices should have changed but did not. Several approaches were needed, training, support, and an additional framework like the TPACK theory needed to be incorporated into teacher education for more success (Garba et al., 2015). Educational technology in the 21st century classroom had amplified and could be sustained with support, training, and TPACK (Garba et al., 2015).

Tondeur et al.'s (2016) meta-aggregative research study focused on the connection between the pedagogical beliefs and educational use of technology. Technology had steadily increased, and teachers have incorporated a variety of technologies in the classroom. Personal pedagogy influenced a teacher's belief about technology integration within the classroom (Tondeur et al., 2016). Teachers selected technologies that aligned with their subject and thoughts about good education. Over time, a teacher's pedagogical belief influenced their experience with technology, which could change their classroom practices with technology (Tondeur et al., 2016). The integration of technology could not be a single event but rather a demonstration of learning that supported technology education in the classroom.

The literature that I reviewed supports my choice of methodology and relates to the research question. The case study methodology and the TPACK framework are appropriate for this qualitative research study. They are appropriate because I explained how individual teachers use technology usage in the classroom. The TPACK model provided three components: TK, CK, and PK that were essential for a teacher's ability to assimilate technology into the classroom (Baran et al., 2017) and I used the components to examine this integration. This qualitative research study will share best practices that science teachers use to teach scientific inquiry skills in middle school classrooms. This research study will answer questions about the importance of successfully integrating technology into the 21st century classroom and using technological tools to teach science content.

## Summary and Conclusion

In this chapter, I summarized the major themes for the literature and discussed how middle school science classrooms had been equipped with different technological tools for science teachers to use to teach scientific inquiry skills (Williams et al., 2017). I described the TPACK framework and how it had been used to assist with the integration of technology in the science classroom in several research studies (McKnight et al., 2016; Rahman et al., 2017) and various factors affected the PK, CK, and TK of science teachers, which affected how they use technology (Jaipal-Jamani & Figg, 2015). I noted that scientific inquiry skills were being taught in science classrooms worldwide with a variety of technological methods (Williams et al., 2017) and that educational technology was important to 21st century classrooms (Garba et al., 2015).

Middle school science teachers were using technology in the classroom to teach scientific inquiry skills, but their best practices for teaching scientific inquiry skills with technology was not known. Gathering information from middle school science teachers who use technological tools to teach scientific inquiry skills in middle school science classrooms to be more meaningful and gainful for students was necessary. The present research study examined factors that involved the best practices used to teach scientific inquiry skills with technology, how the TPACK framework related to teaching with technology, and incorporating educational technology in the classroom.

In this chapter I restated the problem and purpose, provided a concise synopsis of the literature and cited sources that supported and provided evidence for the central research questions recommended in this qualitative case study. The framework was identified while I synthesized the primary writing of the key theorists and researchers. The concept was applied the benefit for the research was established. The related literature was described, justified, and synthesized providing evidence for the research study.

In Chapter 3, the research design, rationale, methodology, and ethics for this qualitative research study are examined.

# Chapter 3: Research Method

The problem addressed in this qualitative case study was that even though technology and technological tools are increasingly used to teach scientific inquiry skills in middle school classrooms, best practices for making their teaching more meaningful are not known. Therefore, the purpose of this research case study was to gather information about the technological tools that could be adopted to make the teaching of scientific inquiry skills in middle school science classrooms more meaningful and gainful to students.

In this chapter, I introduce the research design and rationale. The role of the researcher is defined, along with how I did not impact the research study with professional relationships and biases. The methodology is described to identify the population, sampling strategy, participant criterion, number of participants, procedures for recruitment, and relationship between sample size and saturation. I identify the data collection method and sources. The data collection strategies, participants recruitment procedures and the data analysis plan, along with how I deal with discrepant cases, is explained in detail. I also address issues of credibility, transferability, dependability, confirmability, as well as ethical procedure.

## Research Design and Rationale

This study was designed to explore how teachers used different strategies with technology to teach scientific inquiry skills in the middle school classroom. It was also designed to capture their perceptions about their effectiveness with content, pedagogy, and technology in the middle school science classroom. These four research questions guided the study:

RQ 1: What strategies do middle school science teachers adopt when using technology to teach science in the middle school classroom?

RQ 2: What are the technological tools that middle school science teachers use to teach scientific inquiry skills, and which of these tools do teachers perceive to be more meaningful?

RQ 3: Do the teachers feel that they are quite competent in their pedagogical knowledge to use the technological tools and strategies they adopt to cover up the content that is used in the middle school classroom?

RQ 4: What are the negative and positive factors that are related to their usage of technological tools and strategies when teaching science in the middle school classroom?

For this study, I compared qualitative, quantitative, and mixed-methods research. All three research methods have positives and negatives. A quantitative research study was not applicable for this research study because I wanted more details about the strategies that teachers used in the classroom. I wanted to talk directly with the participants and gain their experience in their own words. Using a questionnaire or survey would be an extra step for the participants (Aydemir et al., 2017) in my research study. A mixed-methods research method was not applicable for this study because I would have to use aspects of quantitative research for the participants, such as questionnaires, surveys, and polls (Hughes, 2016).

I decided to use a qualitative method to capture detailed data from the participants. Among the qualitative designs, I considered using a phenomenological approach but rejected it because this approach focuses on the lived experiences of participants (Strauss & Corbin, 1994). I also considered the grounded theory approach but rejected it because the researcher is creating new theories as data is analyzed and collected (Strauss & Corbin, 1994). I reviewed the narrative approach and rejected it because I want to ask more questions that would yield deeper data (Strauss & Corbin, 1994). I considered the ethnography approach but rejected it because it focuses more on cultural factors and this research study was not focusing on that aspect (Strauss & Corbin, 1994).

For this qualitative research study, I used a case study approach with the TPACK model as the conceptual framework. I decided to use a case study design to gain a greater understanding of how teachers use technology in the middle school classroom to teach scientific inquiry skills (Hilton, 2016; Tokmak, 2015; Williams et al., 2017). This case study design answered the *how* question and was a great way to distinguish the phenomenon from the subject (Hilton, 2016; Tokmak, 2015; Williams et al., 2017). In Hilton's research study, the data were collected from case studies to gain insight for how two veteran teachers incorporated technology in the classroom. The teachers were able to reflect upon their technology use and explain their perceptions of success and failures (Hilton, 2016). In Tokmak's research study, the data were collected from case studies to help participants understand how their TPACK development was perceived while teaching scientific inquiry skills with technology in the middle school classroom. In

Williams et al.’s (2017) research study, a case study approach was used to gain the perception of a teacher that implemented technology to teach scientific inquiry skills in the classroom over two years to support student learning. The data collected yielded which technological tools and strategies used by the teacher were meaningful.

## Role of the Researcher

In this qualitative research study, I was the observer and the primary data collector. I collected data interviewing participants. This research study was conducted at middle schools in the Southeastern part of the United States. I had a professional relationship with all teachers, administrators, and staff members at the school as I used to work at the middle school as a science teacher. The participants are teachers that I had worked with for five years or less. I did not have any supervisory positions while I worked as a teacher at this school. There were no concerns of power or undue influence because I am no longer employed in the school district or at the same school. As such there was no way that conflict or bias could occur.

## Methodology

In this section I identify the population, justify the sampling strategy, state the number of participants and justify the sample size. I discuss the basis for the instrument that was developed for this research study and describe how content validity affects it. I discuss the data analysis plan and identify how the data connects to the research questions, the procedures for coding, software analysis, and how discrepant cases are treated.

**Participant Selection**

The target population for the research study are middle school science teachers who have at least one year of teaching experience in the middle school. The target population was not limited by disabilities or any health impairments. A purposeful sampling strategy was applied to this research study. Ruggiero and Mong (2015) reported purposive sampling would identify and select those individuals with specific characteristics that fit the criteria of a research study to answer the research question. I focused on certain characteristics of the target population. The target participants fulfilled the following common factors: teaching science in the middle school for at least one year and have used technological tools in their classroom.

I submitted my IRB Application to conduct the research. After receiving IRB approval (Approval No. 02-27-20-0398946), I contacted the principal of the school by email to ask for a list of email addresses of the middle school science teachers. In that email I included a confidentiality agreement to assure the principal that the email addresses were only used for the purpose of contact regarding this research study. In the email to the science teachers, I included the description of the research study, the consent form and criteria questions. All middle school science teachers who meet the criteria were invited to participate and were contacted via email. I used a purposeful and criterion selection strategy; therefore, 10 participants were considered to be adequate to provide sufficient answers to the research questions for this research study (Bippert, 2019; Jaipal-Jamani & Figg, 2015). I planned to respond to the first 10 participants who submitted their signed consent form. I allowed for a window of 3 weeks after sending the email to receive responses. The first 10 participants (Minshew & Anderson, 2015) who submitted their signed consent form would receive a confirmation email stating that they were selected to participate in the research study with more details that related to the research study and interview. The consent form includes privacy information, the problem statement and purpose of the research study, along with the social impact of the study to the field of science and technology.

Saturation occurs as data is collected and the same themes or patterns are repeated by the participants. I planned to use the same interview protocol with each of the participants; therefore, saturation would occur by the time I finished the interviews.

**Instrumentation**

The purpose of this qualitative research case study was to gather information about the technological tools that could be adopted to make the teaching of scientific inquiry skills in middle school science classrooms more meaningful and gainful to student. I decided to use an interview protocol (see Appendix A) to collect data. I used the research questions to create detailed interview questions for the interview protocol. No other historical or legal documents were needed as a source of data for the interview protocol. Aydemir et al. (2017) stated that interviews were individualized semistructured data collection tools that can help a researcher focus on the interviewee.

The interview protocol was developed by me. All questions were developed based upon the focus in the research and literature sources of the research study. The questions were placed in a table format to note how the interview questions relate to the research questions. Content validity was established by citing the research questions and literature sources as they correspond with the question. All research questions were linked to the interview questions in tabular format (see Appendix B). The questions all pertained to the expertise of the middle school science teachers as specialists in their field teaching science and incorporating technology.

**Procedures for Recruitment, Participation and Data Collection**

I received IRB approval, and began recruitment for my research study by contacting the principal of the school and asking for a list of email addresses of current science teachers who meet the criteria. I sent introductory emails to all science teachers with the consent form about the research study. The introductory email included the description of the research study, the consent form, potential interview dates and times, and participant criteria for the research study. I allowed for a window of 2–3 weeks wait-time for replies. I would accept the first five signed consent forms for the research study and send those participants a confirmation email with their teleconference interview date and time. As a result of school closures due to the coronavirus pandemic it became impossible to recruit ten participants. I have explained the modifications to the research study in Chapter 4.

The data were collected by me through teleconference interviews. I asked the participants to make sure they are located in a quiet and private environment. I conducted the interview and collected the data at the agreed upon time. This was a one-time interview. The interview lasted about 60 minutes. The data were recorded, and the teleconferencing software was used to record the interview. The participants exited the study with instructions to contact me with any questions they may have related to their responses and a request to email a lesson plan where they are using technology to me. They received their online gift card via email within 3 business days. If any participant chose to exit the research study early, they were thanked for their willingness and response. No one chose to exit the research study early. For my follow-up, I contacted the interviewees to ask additional questions about their responses. I reminded them that they can receive a transcript of their responses to the interview questions to review. If participants agreed with the transcript, no further action would be needed on their part. If they disagreed, then they could correct the transcript and return it via email. The participants declined to receive a transcript.

A deductive coding software, NVIVO was used to decode all data in the research study. The decoding software was used to decode and analyze all four research questions. Before starting the interviews, I developed a basic codebook (see Appendix C) according to themes and research questions. I applied line-by-line coding to analyze the data to include all the details. I categorized the data according to the themes already present in the codebook. If new themes emerged, they were included in the codebook. Discrepant cases were handled as they arose. If a participant gave a vague response, I asked probing questions and asked for more clarification to resolve the discrepancy. A transcript of the interview was created and made available.

## Trustworthiness

In this section I discuss credibility, transferability, dependability, and confirmability about this research study. I also discuss the ethical procedures that were related to this research study this research study.

**Credibility**

Establishing credibility is one of the most important pieces of qualitative research studies and refers to the accuracy or trustworthiness of the data (Statistic Solutions, 2019). I used member checks to ensure the accuracy and trustworthiness of the data. The interview data were transcribed. The participants were offered a copy of the transcript for their interview to clarify their responses and correct any errors. The participants declined to receive a copy of their transcripts.

**Transferability**

Providing thick, rich descriptions is important and determines how findings are transferred. I provided detailed explanations about the study and the techniques I used to collect and analyze the data. I created a researcher's journal with detailed and thick descriptions of my experience interviewing the participants. I discussed the interviews which were conducted via teleconference and I asked the participants to describe their setting. I described if the interview was taking place before work or after work for my participant.

**Dependability**

Dependability refers to whether the results are consistent with the data collected (Statistics Solutions, 2019). Dependability also referred to the steadiness or reliability of the process of inquiry. Participants were selected based upon their teaching assignment, having one year of teaching experience, and using technology in the classroom. The consent form was sent to all science teachers at the school, and I selected the first five teachers who sent back their signed consent form. I used member checks and the actual interview notes to establish reliability. I used the interview notes and transcripts to triangulate the data. I had an outside researcher examine the data collection process, data analysis process, and results of the research study to confirm the accuracy of the findings. The external auditor was another colleague who was familiar with analyzing and interpreting data. I checked the audit trail and looked at how the data were recorded to establish dependability for the research study.

### Confirmability

Confirmability is the extent to which the research findings are confirmed by others. I used a specific coding procedure to ensure the dependability of the data and kept a detailed notebook which contained the dates, times, and places of each interview. Verbatim data were included in the notebook from each interview. Categories and emerging themes were captured during the interview. The notebook included detailed notes about the processes I used to collect, analyze, and interpret the data. I placed specific responses together according to theme and explained the meaning of the theme and rationale for how it related to the research study, as well as related the theme to literature, and related to the research.

## Ethical Procedures

I received permission from the school district to conduct the research study at the school. I followed all protocols the school had to conduct the research study. The Walden Institutional Review Board's approval was needed to conduct this research study. I submitted the required application and all related materials, to obtain approval. I attached approval from the school or school district granting permission to conduct the research.

Once permission was received from The Walden Institutional Review Board, I proceeded with conducting the research study.

Human participants participated in this research study. The human participants were treated fairly, and justly, according to the National Institutes of Health. I completed the National Institutes of Health Ethics training in September 2018 and received the certificate of completion. No undue stress or harm was anticipated in this research study for the participants.

The research study was conducted in two middle schools where I had previously worked. I had established professional relationships with some the of the faculty and staff members at the middle schools. My professional relationship with the faculty and staff did not impact my role as a researcher for this research study. I abided by the rules set forth for the qualitative research study where I recorded responses verbatim. I recorded each participant's words carefully and asked follow-up questions if I did not understand them clearly. I developed transcripts of the participant's responses from the interviews and kept a reflective journal of my own thoughts and referred to the journal as I looked over the transcripts of the interviews to avoid confirmation bias.

The data were coded, confidential, and anonymous. To keep their responses confidential, each participant was assigned a number and letter combination: P1, P2, P3, P4, and P5. The data were kept in a password-protected secure file on a secure hard drive. I have the password for the file. I have a secure data back-up system in place in the case of file corruption or damage. All papers that were generated as a result of this research study are locked in a secure location with a confidential password that I can only access.

The data will be kept secured for 5 years and then destroyed. The data includes interview responses, interview audio recordings, transcripts, signed informed consent forms, and any email communication with the participants.

## Summary

In Chapter 3, I introduced the chapter and identified the research design, rationale, and role of the researcher. I established the methodology for this research study. The methodology was described in detail for replication of the research study. I described the process for conducting the research study beginning with submitting the application and ending with how the participants will exit the study. I discussed how the research study will be conducted and data analysis plan. All relevant appendices were named and included in the chapter. The issues with trustworthiness were identified and explained. I explained how I would handle credibility, transferability, dependability, and confirmability. Ethical procedures were discussed, and strategies to solve issues were described.

Chapter 4 identifies the data collection and data analysis processes. Tables and figures are presented as data is analyzed and displayed.

# Chapter 4: Results

The purpose of this qualitative research case study was to gather information about the technological tools that could be adopted to make the teaching of scientific inquiry skills in middle school science classrooms more meaningful and gainful to the students.

My focus in this chapter was central to the research questions used in the study:

RQ 1: What strategies do middle school science teachers adopt when using technology to teach science in the middle school classroom?

RQ 2: What are the technological tools that middle school science teachers use to teach scientific inquiry skills, and which of these tools do teachers perceive to be more meaningful?

RQ 3: Do the teachers feel that they are quite competent in their pedagogical knowledge to use the technological tools and strategies they adopt to cover the content that is used in the middle school classroom?

RQ 4: What are the negative and positive factors that are related to their usage of technological tools and strategies when teaching science in the middle school classroom?

In this chapter, I describe the research study setting, along with the external conditions that may have influenced the participants' involvement in this study. In particular, the closure of the schools due to the coronavirus pandemic resulted in changes to the study. The demographic information relevant to the research study is also presented. The strategies adopted for data collection and the analysis process are described. The tactics used for coding, categorizing, and thematic analysis processes, as well as any resulting discrepancies, are described in detail. Factors associated with trustworthiness, credibility, transferability, dependability, and confirmability are adequately dealt with.

## Study Setting

This study was conducted in two suburban middle schools in the southeastern region of the United States. Both served Grades 6th, 7th, and 8th. The population of the schools were 905 students in the first school and 525 students in the second school. In the first school, roughly 80% of the student population were White, 18% were Black, and 2% were Asian, Biracial, or Pacific Islanders. There were 65 faculty and staff members; 11 White female and 2 White male staff members taught science. This campus had an economically advantaged population of students, where approximately 90% of students had technological devices and Internet access at home (see Figure 1).

In the second school, roughly 94% of the student population were Black, 6% were White, and 1% was Asian, Biracial, or Pacific Islanders. There were 45 faculty and staff members; three White female and five Black female staff members taught science. This campus had an economically disadvantaged population of students, where approximately 80% of students did not have technological devices and internet access at home (see Figure 1).

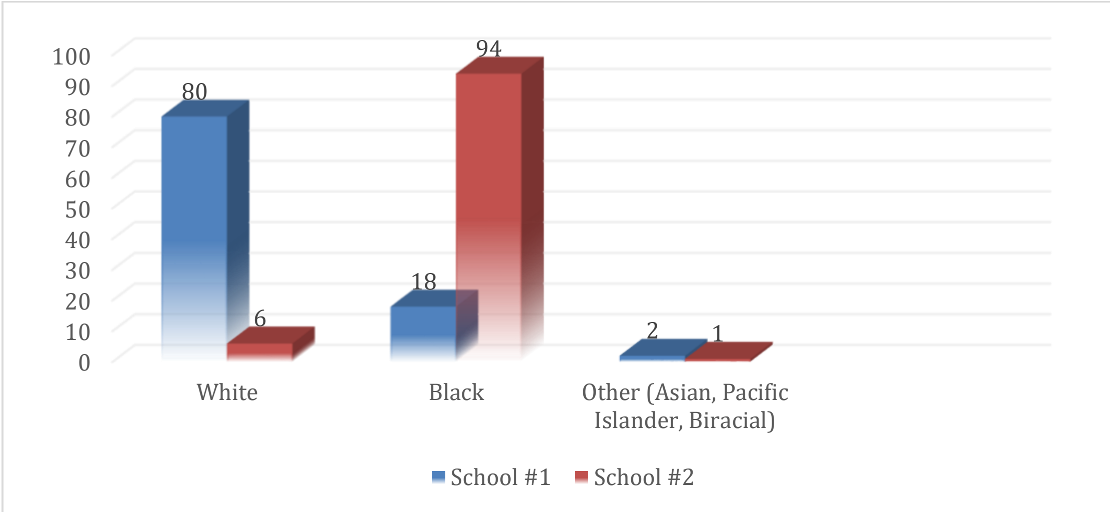


*Figure 1*. Student population.

This study's data collection began as the coronavirus (COVID-19) pandemic struck the United States. I had difficulty contacting the school principal for the first school. All nonessential businesses were closed, including schools, colleges, and universities due to the coronavirus (COVID-19) Pandemic. Due to this difficulty, I decided to add a second school to the research study. The research agreement with the school district did not limit me to one school. A second IRB approval was not needed.

I emailed the principal of the first school twice, allowing 2 weeks in-between emails for a response. I did not receive a response. I finally reached out to former colleagues who were not related to the research study and asked that they contact the principal for a response. After 4 weeks of waiting, I received a response with the names and email addresses of possible participants from the first school. I composed and sent emails to those potential participant teachers. Only three out of the seven teachers I emailed consented to participate from the first school. I realized that number of participants was not sufficient for the research study.

After discussing this issue with my committee, I realized that I should not limit my study to one middle school in the area. I received prior approval from the school district to contact any school in their district; therefore, I contacted the principal at a different middle school for possible teacher participants' names and email addresses. After a week of waiting, the principal replied with a list of names and email addresses. I contacted those teachers via email requesting their participation in the research study. Out of the eight teachers, only two responded and consented to participate in the research study, therefore giving me a total of five participants.

Due to the geographic distance between myself and the participants, the interviews were scheduled to be conducted by teleconference. The five participants included possible dates and times for their interview in their consent emails. I confirmed the dates and sent each participant a link for their teleconference interview. Shortly after, there was a rapid and sudden school closures, making it difficult to secure participants for this research study. Since the original number of participants changed from ten to five, the Research Committee and URR were also consulted. Due to the unexpected conditions, approval to use a lesser number was approved as other qualitative case studies have been conducted with fewer participants (Williams et al., 2017). The lesson plan reviews and follow up questions helped to make this study as robust as possible under the circumstances.

## Demographics

The participants in this research study were middle school science teachers who had been teaching middle school science for at least 1 year and have used technology in their science classroom. The participants were from two different schools. The five participants were all White female teachers. The range of their years of teaching varied from 5-30 years. All participants taught science, with one participant teaching math in addition to science (see Table 1).

Table 1

*Demographics*

| Participant | Years of experience | Grade level | Subject taught |
|---|---|---|---|
| 1 | 18 | 6th | Science |
| 2 | 7 | 6th | Science |
| 3 | 23 | 7th | Science |
| 4 | 30 | 8th | Science and Math |
| 5 | 5 | 7th | Science |

## Data Collection

In this research study, data were collected from three sources, the initial interview, the follow-up email, and the lesson plans. The participants were middle school science teachers from two different schools who had been teaching middle school science for at least one year and had been using technology in the classroom. Each participant consented to the initial interview via teleconference and consented to submit a lesson plan. The data were collected via teleconference while the participants were in their homes, which they felt was the most comfortable and convenient place to conduct the interview.

Each participant received a confirmation email with the date and time of the interview, confirming their participation in the research study. At the scheduled time, each participant logged onto the Zoom link that was sent in confirmation email. The Zoom teleconference was audio-only. The participants were thanked for their willingness to participate in the research study, and each participant was reminded that the Zoom teleconference was being recorded. All five participants were at their home for the interview in a comfortable location of their choice which was free from distractions.

I began the interview with the first interview question. The participants were asked about their years using technology to teach scientific content. The participants discussed their comfort level with technology. They all indicated that they were comfortable using basic technological devices like laptops and tablets. They also discussed using technology at home to stay abreast of current technology trends. The participants' years using technology spanned from 2–20 years.

Each teleconference lasted approximately 60 minutes. The interviews were recorded using the teleconference software, Zoom. Some participants gave one-word responses, and I asked probing questions to obtain additional responses from the participants. I was careful not to monopolize the conversation but made an effort to get the participants to respond to my questions in detail.

The participants emailed their lesson plans to me. I asked the participants if there was a universal lesson plan template, they all used, and their responses were no. They stated that the lesson plans only needed to include the standard, the objective, the focus question, the procedures, and the assessment. The lesson plans were analyzed according to the lesson plan codebook (see Appendix I) for the scientific inquiry skill taught, technology tools used, and technology instruction, as described in the section on data analysis.

Because the number of participants were limited, I planned to conduct follow-up interviews with the participants. I sent follow-up emails to the participants approximately two weeks later, asking the five participants if they could participate in a follow-up interview. The official school year had ended; therefore, I contacted the participants via email asking for another teleconference interview and three out of the five agreed to answer additional questions. The three participants did not consent to another time to speak with me but expressed interest in having the questions emailed to them. I agreed and emailed the follow-up questions to the three participants and requested they send back their responses within three days, and all of them very kindly fulfilled this request.

## Data Analysis

The process of analysis which includes the interview and lesson plans are organized by RQs. In this section, I describe the data analysis for each of the three data points: interviews, lesson plans, and follow-up emails. As the analysis for interview and follow up differed from that for lesson plan, I have separated them into two sections. I used the components of the TPACK model to explore how the four themes: teaching strategies, technology tools used, teacher competency, and positive and negative factors with technology are embedded into how the participants interact with their students. The

TPACK model combines content knowledge, pedagogy knowledge, and technology knowledge. All three are needed to successfully teach technology in the classroom.

**Initial Interview and Follow-up Emails**

Three days following the interviews, each interview was transcribed using an online transcription service. Since all five participants declined to view their transcripts, I had a colleague check the transcripts against the interview audio for discrepancies and errors. None were found; therefore, I copied the transcripts to NVivo to categorize the data according to pre-established themes. The following pre-established themes were based on the research questions: teaching strategies, technology tools used, teacher competency, which covers pedagogical knowledge and content knowledge, and positive and negative factors with technology. I sent follow-up emails to gather more experiences of the participants' use of technology in the classroom and gather more meaningful data. I composed an email to the participants (see Appendix D). The email was sent within two weeks of the teleconference, and the participants were asked to respond within three days. The responses to the four questions asked were crossed-referenced with the previous responses. In comparison, the responses were the same from the initial interview. There were no new themes that emerged nor new coding needed for the responses.

Data classification was easier when I used the research questions as guides to create the themes. The coding process yielded the following categories for the themes. For RQ1, teaching strategies: authentic learning and project-based learning. For RQ2, technology tools used, hardware, software, and peripherals. For RQ3, teacher competency: pedagogy knowledge and content knowledge. For RQ4, positive and negative Factors with Technology: student performance and teacher technology knowledge. I explained more about these categories under each research question below (see Table 2).

Table 2

*Coding of Data and Research Questions*

| Theme | Research question | Category |
|---|---|---|
| Teaching strategies | r1 | Authentic learning (online publishing, podcasts and videos), project-based learning (student choice, differentiation) |
| Technology tools used | r2 | Hardware, software, peripherals |
| Teacher competency | r3 | Pedagogy knowledge, content knowledge |
| Positive and negative factors with technology | r4 | Student performance, teacher technology knowledge |

The next section describes how the theme connects with the research question. The theme is explained, and examples are included to show how they relate.

**Research Question 1**

R1: What strategies do middle school science teachers adopt when using technology to teach science in the middle school classroom?

The theme of this question was teaching strategies. There were two categories that emerged from the data analysis: authentic learning (online publishing, online podcasts, and videos) and project-based learning (student choice and differentiation). One authentic learning strategy was online publishing. P5 stated, “I use Google Slides and post my lectures online. The students take notes at their own pace reading my post.” Another authentic learning strategy was using podcasts and online videos to increase content knowledge with students. For authentic learning, the participants used real-world knowledge in an online and mobile learning environment, Google Classroom by posting the tasks that students were expected to complete. P4 stated, "I use Google Classroom to post my Pendulum Lab videos and directions. Students were expected to follow the directions to gather data and complete the lab. I want them to understand the value of mass." P2 also used Authentic Learning and posted directions for the students to "use the outside weather stations to gather data about today's weather and forecast tomorrow's weather." P2 stated further, "students will learn more about weather when they are interacting with it in real-life."

Project-based learning (PBL) was used as participants assigned a project that students had to complete on their own. One PBL strategy was using the Tic-Tac-Toe Student Choice Board Project Board. P3 stated, "We do PBL. I give students a choice of at-home projects for students to complete in Google Classroom." P5 used Project-Based Learning by giving students an option for a formative assessment. P5 stated, "Students have to make a weather map forecasting the weather for three days, and they have to show their home on the map. Students can create an actual map or one online." Follow-up questions were not required for RQ 1, because the interview responses were clear and consistent.

**Research Question 2**

R2: What are the technological tools that middle school science teachers use to teach scientific inquiry skills, and which of these tools do teachers perceive to be more meaningful?

The theme that emerged was technology tools used. Three categories emerged from the data analysis: hardware, software, and peripherals.

The hardware used included Apple iPads, Google Chromebooks, document cameras, temperature probes, stopwatches, and calculators. P1, P2, and P5 were given a classroom set of Google Chromebooks for use in their classroom. P1 stated, “I have a class set Chromebooks, and I use them daily with my students. I am lucky because not all teachers received a class set. I don’t have to search and borrow from someone else. I also have a working document camera.” P3 did not have a classroom set of Google Chromebooks or Apple iPads. P3 stated, “Students in our grade level, we are one-to-one, and devices were issued at the beginning of the year, and they keep them and bring them to class. It could be a Chromebook or an iPad.” P4 had a classroom set of Apple iPads to use. P 4 stated, “I have iPads and I use those in class with the students and we also use stopwatches with the Pendulum lab and iPads.” P4 recalled teaching a lesson where the objective was to compare and contrast different animal habitats. In relation to the technological tools used, P4 wrote:

> Students will complete an article analysis about animals, comparing and contrasting their habitats. The students will use the iPads to read articles and

answer questions about the animal habitats. They can select and complete two articles, but they MUST receive an 88 or a 100, or it does not count.

P3 and P4 expressed some frustration with always having to borrow Google Chromebooks or even Apple iPads from another teacher. The participants expressed that there was a limited number of Google Chromebook carts and sets of Apple iPads in the school to share. P4 pointed out the difficulties they faced when using technology, “I have iPads, but I can’t use them all the time for interactive labs, and it was hard to borrow Chromebooks when the teachers were using them. There are no extras in the school.” Each participant agreed that due to the limited number of technological tools available, all teachers cannot have access to technology. P4 also stated, “We are expected to use technology because we received the grant, but because it’s hard when you can’t access the technology you need.” It was clear from the opinions expressed by the teachers the lack of access to technology all of the time affected their technology competency. This was evident from some of the ideas that emerged when question 4 was discussed with the participants.

The software that was commonly used included Google Suite software and Adobe Flash Player. The Google Suite software included: documents, spreadsheets, presentations, and surveys. All participants used the Google Suite Software along with Google Classroom for student work. P1 stated, “The students use Google Docs to type their responses and post in the classroom.” P2 stated, “We use Google Slides to take notes. I post the slides in Google Classroom and the students read them and take notes from the slides." P3 adopted a different approach as she stated, "I use spreadsheets and Google Sheets are easy to connect in Google Classroom for the students to access."

The Adobe Flash Player software could only be used on Google Chromebooks. P1 stated that "Chromebooks help kids gather data quickly and in-depth. The flash player is good for interactive websites, like Nearpod." P2 and P4 also stated, "the Adobe Flash Player software does not work on iPads because iPads are not compatible with the Adobe Flash Player software." Furthermore, their responses indicated that peripherals are used as needed. There are headphones, computer mice, and mousepads available. P1 stated, "I keep a few computer mice in my class for students who struggle with clicking." P5 stated, "I keep a few headphones available for students. But the expectation is they bring their own headphone or earbuds to class."

In the follow up email, I asked the following question related to how technology tools were used. Q1: Can you describe how you use technology to teach scientific inquiry skills? P2 described using technology for online videos and virtual labs. P3 stated, "A typical unit would be an introductory lab and students would explore the information, I would give a lecture, and then we do a lab." P5 used technology "mostly for lectures and videos, to show the students multiple forms of the same thing. I also use technology for PBL and research."

The second question in the follow-up email was Q2: Are there any specific technological tools that you favor in your classroom and why? P2, P3, and P5 all replied Google Chromebooks. The responses were similar "Google Chromebooks use flash player and students can access online lab simulations." The coding process also yielded two subcategories: helpful technology and nonhelpful technology. Helpful technology was technology that is useful in learning and is multifunctional in use. Nonhelpful technology was technology that was not useful in learning and was not multifunctional in use.

Helpful technology referred to using Google Chromebooks because of the multifunctionality of the device. The participants were adamant that the Google Chromebook had more versatility to surf the web and use interactive websites. The device had a screen, touchpad, and keyboard which made it easier to use and navigate websites. Students were able to type and submit assignments online easily. This was apparent within the responses of the participants. Helpful technology also referred to other laptops, tablets, calculators, scales, stopwatches, and other various scientific equipment used in class. Specific software programs were considered helpful technology. The Adobe Flash Player software was mentioned by each participant as being important for the success of accessing interactive websites, like Nearpod and Explore Learning Gizmos: Math and Science Simulations. Some participants had computer mice; another helpful technology available for students who struggled with using the touchpad. Students brought their earbuds or headphones, more helpful technology to use with their device.

There were not enough technological devices available for each student to have one. The lack of available devices was not helpful for student learning. Nonhelpful technology referred to the use of Apple iPads and their lack of multifunctionality and limited use. Apple iPads were limited in navigation and accessibility to online labs and simulations that require Adobe Flash player software. Other nonhelpful technology were the science probes that were old, outdated, and no longer sustained by the school or company. A few participants mentioned that they were no longer used because the probes no longer work properly, and there were newer versions but no funding to purchase them. “The science department has a few temperature probes that do not work” (Participant 3, personal communication, May 5, 2020). One participant mentioned there was a cabinet of nonhelpful technology. P2 stated “there are devices that are either broken, old, or no one remembers how to use them.”

**Research Question 3**

R3: Do the teachers feel that they are quite competent in their pedagogical knowledge to use the technological tools and strategies they adopt to cover the content that is used in the middle school classroom?

The themes that emerged were teacher competency with pk and ck. P1, P2, P3, P4, and P5 felt they were competent with using pedagogical knowledge to teach scientific process skills. P1 stated, “I love teaching labs where we collect data. We use the Chromebooks to collect and organize it for the lab.” P2, and P4 discussed “liking the flexibility of technology with hands-on lessons.” P4 stated, “I love technology and being able to incorporate it into my lessons is great. I make sure my students are focused, and I always monitor them while they are on the computers.” All participants discussed the content they taught. P1 stated, “I teach earth and physical science concepts. I have been doing this for many years. I like certain lessons better.” P2 stated, “I prefer scientific process skills. I love to teach data collection. That is the fun part.” P3 stated, “I love teaching about the human body. That is my favorite unit. I have been teaching that for over 12 years now. I think I have it down." P4 stated, "I love geology. I like teaching about rocks and minerals. I incorporate the scientific method into it, and I get great results." P5 stated, "My experience is growing. Each year I get better with my content. My favorite is weather and animals. My students and I thrive with it" (see Table 3).

Table 3

*Competency Matrix*

| Content subject | Technological tool adopted | Participant usage |
|---|---|---|
| Earth Science | Chromebooks, document camera, stopwatches | P1, P2, P4 |
| Life Science | Chromebooks, iPads, temperature probes, | P3 |
| Physical Science | Chromebooks, document cameras, temperature probes | P1, P2, P3, P5 |
| Scientific Process Skills | Chromebooks, iPads, document camera, stopwatches, temperature probes | P1, P2, P3, P4, P5 |

Some participants spoke about the challenges of teaching scientific inquiry skills online without the hands-on learning component. P3 stated that "before the coronavirus, we were able to be hands-on with tech, now that we are virtual, the hands-on is missing." P4 also stated, "Now that we are virtual, I am not able to teach like I used to, we had to adjust, and it is not the same." Due to the coronavirus pandemic, all teachers felt that they were not as effective as they were when they were teaching face-to-face with their students. When asked if all students benefit equally from the use of technological tools before the school closures, all participants replied no. P1 stated, "They benefit from them, not equally. It is an extra resource for them. There is a misconception that you see it on a computer screen." Participant 2 stated, "Learning styles are different. We monitor and adjust. Kids who use tech will click anything just to turn something in. We try to use personalized instruction. Not all students benefit from technology or personalized learning." P3 stated, "Some kids need more guidance than others. The benefit is the same collectively. I didn't get anything. Technology helps all students. There isn't one way for all students." P4 stated, "In a way, it evens the playing field during the school day. Not at home because technology waivers and differs at home." P5 stated, "No, Kids are kids and they distract easily. No program to monitor the computer. They get lost in YouTube and games. They don't take the things as seriously." P5 also displayed pedagogical knowledge by starting the lesson with a Warm-Up Activity for the students. After the Warm-Up Activity, a demonstration of the Lab Activity was completed, and questions were answered by the teacher. Next, students completed individual practice by completing the activity. Last, students completed an assessment with the Exit Ticket.

**Research Question 4**

R4: What are the negative and positive factors that are related to their usage of technological tools and strategies when teaching science in the middle school classroom?

One positive factor with using technology was that Google products were used as an alternative for displaying science content for students. P3 felt that "utilizing Google Slides and Google Classroom for notetaking was great for allowing the students to work at their own pace." P3 also noted that "online lab simulations and Google Forms are easy for the students to fill out. Therefore, they are used often." P2 noted that "before the coronavirus pandemic, Google Classroom was used once a week. Now it is used daily with online learning. Digital websites like YouTube and Vimeo are used, as well as virtual field trips." Other positive factors involved P4 and P5 using online educational games as incentives for students to complete their work in class. They stated very clearly, "I use Kahoot as a reward for students. We play a fun round after they finish their work."

The main negative factor all participants emphasized was about the use of iPads for learning. The participants felt that iPads only offered a few good features. According to what the participants stated, it was difficult to use them for any online interactive websites. They lacked Adobe flash player which is a key component for the interactive websites to work, and the lack of a keyboard made it difficult for students to log into and log out of the device properly. The iPads were not built for stability and could not be placed at an angle on the table for maximum functionality and view. The above point was proved by the following statements of P1, "iPads are not good for Gizmos, the flash player will not work at all." P3 stated "iPads are not easy to log into and out of because there is no physical keyboard." The participants said there was no additional funding for attachments, like portable keyboards and hard iPad cases, to make the iPads more accommodating for the students to use. In addition, P3 stated, "Once the technology grant funding ran out, there was nothing left to purchase portable keyboards and stationary hard iPad cases with." Another negative factor related to the use of technology was made clearly when P1 and P2 reiterated that students could become bored with technology. P2 stated, "students tend to become bored with the same routine. Using technology daily can present a problem, because the students tend to rush through their work just to finish early."

In the follow-up email, I asked 2 additional questions related to positive and negative factors with technology usage. Q3: How did they use technology without taking away from their teaching style? P2 said “Teachers care about what they are talking about and I want them (students) to hear my voice and I hear their voice. Tech is good to present information and assess how much they understand of that information, but I talk to my students. P3 expressed the routine she adopts when she said, “Most of the time I use technology to display my PowerPoints or videos, I am not a huge technologically savvy teacher, but I get by.” P5 stated, “it varies and depends on what is being taught in the classroom. Different content requires different activities and technology.”

Q4: What intrigues you most about technology? P2 stated “As technology programs grow, more money can be funneled into them leading to a good balance of technology in the classroom.” P3 said “I learn new things. Having tech helps me do that. Especially in Astronomy. Learning about new discoveries.” P5 stated, “Students have different resources in front of them. They can look things up and get a different point of view.”

**Lesson Plans**

After the data from the interview questions were analyzed I focused on the lesson plans obtained from the participants and analyzed the content based on the format provided in Table 4 (see Table 4).

Table 4

*Lesson Plan Evaluation Table*

| Four aspects included in the lesson plan | Questions used when evaluating the lesson plan | Relationship to the research questions |
|---|---|---|
| Objectives | Does the objectives embedded in the lesson plan show any evidence of the use of technological tools? | RQ1 |
| Focused questions | Does the questions included in the lesson plan show that different strategies are used by the teachers during the lesson? | RQ2 |
| Procedures | Does the procedures adopted by the teachers when developing the lesson show that technological tools are used by the teachers during the lesson | RQ2 |
| Assessments | Does the assessment system adopted show any indication that the students are encouraged to use technology? | RQ3, RQ4 |

Lesson plans were submitted by each participant and analyzed according to the four aspects: objectives, focused questions, procedures, and assessments listed in Table 4. Each participant taught either 6th, 7th, or 8$^{th}$ grade science. I noticed that the 6$^{th}$ grade lesson plans focused on the environment, the 7$^{th}$ grade lesson plans focused on body systems, and the 8$^{th}$ grade lesson plan focused on physics. The lesson plans were used to corroborate the participants’ responses to teaching scientific inquiry skills with technology. The lesson plans were only used for that purpose.

I began my analysis by looking at each lesson plan for the objective and science content standards. I applied the first question *Does the objectives embedded in the lesson plan show any evidence of the use of technological tools?* For each lesson plan, the response was yes. While the science content standards were different, the scientific inquiry skill standards were similar. The scientific inquiry skills: gathering data, communication, and data analysis were all included in the lesson plans. Each lesson plan included a technology tool, as well as a data collection task. Students were completing different tasks on the iPads or Chromebooks. P1 noted, "students will log into their Chromebooks and complete the Daily Science Warmup." P2 stated, "the teacher will use the document camera and demonstrate how to fill out the data worksheet." P3 was completing the Pendulum Lab and wrote "the students will use a stopwatch to collect data by recording the number of swings from the pendulum in 30 seconds." P4 wrote, "the student will be able to collect data using the triple beam balance scale." P5 stated, "using the iPads, students will record themselves giving a 60 second weather forecast."

I then looked for the focus question and applied the second question *Does the questions included in the lesson plan show that different strategies are used by the teachers during the lesson?* For each lesson plan, the response was yes. The questions included in the lesson plan showed that the teachers used different strategies. The information derived from the lesson plans related to different aspects were described below. In her lesson plan P1 wrote, "What is the difference between a metal and a nonmetal?" The lesson plan also revealed that P1 used an Authentic Learning strategy where the students had a selection of everyday objects to categorize as metals and nonmetals. In her lesson plan P2 stated, "the student will jump, hop, and walk backwards, tracking the time it takes for them to travel 50 feet." P2 also indicated that she used an Authentic Learning strategy, applying real-world actions with the activity. The focus question that related to the above activity was *What is the speed of a student has who hopped 50 feet?* P3 wrote, that "she will have the students to count the number of swings in a 30 second period with a stopwatch." This Authentic Learning strategy used a stopwatch to record time. The focus question related to the above activity was *How many swings can the pendulum make in 30 seconds?* P4 and P5 used Project Based Learning strategies. In their lesson plans it was stated that the students will watch videos and complete different tasks to create personal projects based on the focus question. P4's question was "*How can the triple beam balance scale be used to weigh objects*?" P5's question was *"How can you forecast the weather?"* In the lesson plans of both P4 and P5 the students were made to create graphs and video projects to achieve the intended objective.

Next, I looked at each lesson plan for the procedures. The third question was applied, *Does the procedures adopted by the teachers when developing the lesson show that technological tools are used by the teachers during the lesson*? For each lesson plan, the response was yes. Each materials section of the lesson plans listed technological tools like Chromebooks, iPads, stopwatches, triple beam balance scales, and calculators. It was planned to make the students use technology to complete in-class activities. In the Procedures section of each lesson plan, the teachers also included the tools in their directions. According to what was included in the lesson plan of P1, "The students will use the Chromebook to research the different objects to classify them as metal or nonmetal." In P2's lesson, it was indicated that the "students would use the stopwatch to time how many times a student can hop in 30 seconds." In relation to the same P3 had written "The students will use the calculator to calculate the average number of swings in 30 seconds with three washers." P4 had indicated that "the students would weigh each object on the triple beam balance scale and record the mass on their spreadsheet using the iPad." P5 wrote in her lesson, "Students will use the iPad to record a 60 second video of themselves giving a weather forecast." Thus, it was evident that the contents of the lesson plans confirmed what the participants responses indicated.

Last, I looked at the lesson plans for the assessments and applied the 4th question: *Does the assessment system adopted show any indication that the students are encouraged to use technology?* For each lesson plan the response was yes. All lesson plans incorporated technology into the assessment. P1, P2, P3, P4, and P5 incorporated the Promethean Board to display student work and exit tickets. Students used either the iPad or Chromebook to complete the exit ticket before leaving class. What the participants had written in their lesson plans in relation to the assessment system was described below. For example, in her lesson plan P5 wrote, "What is the importance of weather forecasting to society?" Student had to type their response in the Google Doc and submit it. P4 wrote, "Students will use their device to complete the Google Form Exit ticket." P3, P2, and P1 wanted students "to type their exit ticket response in the Google Classroom comments under the question."

Thus, after the comparison of the data from the Lesson Plan Codebook with that of the data from Interview Codebook it was evident that the content was similar to what the participants said and what they wrote. One similarity was using technology in the classroom to deliver information. The participants described using Google Classroom as an information portal to disseminate information. They also listed Google Classroom in their lesson plans as a software tool the students used to find and input information. P3 stated “I post all of my assignments in Google Classroom for the students to find. I also post copies of their documents there.” P3 wrote in the lesson plan that “students will access Google Classroom to find their assignment for the day.”

Another similarity was using technology to complete classwork and tasks. The participants described using Google Chromebooks, iPads, and scientific equipment to complete labs, assessments, and projects. In the lesson plans, they listed the same equipment under the Materials section and in the Procedures section. P1 said, “We use Chromebooks to complete our daily science work.” P1 wrote under Procedures “1. Students will go to their desk and open the Chromebook, log in to Google Classroom, and complete the daily science work listed there.”

One final similarity was the use of pedagogical skills to teach content. P5 stated, “I split the class into groups of 4 to make the project more manageable and split the responsibilities in the group. I can work with each group this way.” P5 wrote, “Students will work in groups of 4 to complete the project. The teacher will assign roles in each group. The teacher will monitor and adjust each group as needed.”

The lesson plan analysis also revealed each lesson plan had objectives, science content standards, a focus question, procedures, and an assessment. The teachers used technology and pedagogical skills to teach science content and scientific inquiry skills to their students. They used different strategies and materials to engage the students and keep them focused on learning.

## Evidence of Trustworthiness

In this section, I discuss how the factors related to trustworthiness of a study namely credibility, transferability, dependability, and confirmability are safeguarded in this research study.

### Credibility

Establishing credibility was one of the most important pieces of qualitative research studies and referred to the accuracy or trustworthiness of the data (Statistic Solutions, 2019). In my study, member checks were used to ensure the accuracy and trustworthiness of the data. The interview data were transcribed, and the opportunity was given to the participants to review their responses. The participants opted not to review their responses; therefore, they did not receive a copy of their interview transcript. However, the follow-up email questions allowed me to ensure the accuracy of their responses.

### Transferability

Providing thick, rich descriptions were important and can determine how findings can be transferred. I provided detail explanations about the study and the techniques used to collect and analyze the data. I created a researcher’s journal and detailed my experience interviewing the participants. All interviews were conducted via teleconference. All participants were at home when the interview was conducted due to the coronavirus pandemic. The above adopted measures ensured the transferability of this study.

**Dependability**

Dependability refers to whether the results were consistent with the collected data and the reliability of the inquiry process. (Statistics Solutions, 2019). I used member checks, interview notes, and the follow-up interview notes, as well as analyzing the content of the lesson plans to establish the reliability and triangulate data. An external auditor was used to examine the data to establish dependability for the research study. The results were consistent with the data. The inquiry process was reliable and conducted in a consistent way.

**Confirmability**

Confirmability was the extent to which the research findings were confirmed by others. I used a specific coding procedure to ensure the validity of the data and kept detailed notes which contained the dates, times, and places of each interview. Verbatim data were included in each interview. All interviews were transcribed. All emerging themes were captured during the interview. Specific responses were grouped according to the theme, and the explanation for how it related to the research study was noted. I also examined the results that emerged with the existing information in the literature review.

## Results

The results of the analysis for all three data points are discussed and organized by RQs. RQ1 results revealed that the participants used authentic learning and project-based learning (PBL) as strategies to teach scientific inquiry skills to students. The participants discussed how they used different strategies like real-time feedback with online assessments and posting assignments in the Google classroom to teach scientific inquiry skills. The lesson plans submitted by the participants showed their use of Google Classroom as a real-time location to post assignments and feedback for each student. The lesson plans also reflected the strategy used, listing the websites and online assessments along with instructions for completion. As participants described the strategies they used in their classroom, the themes became evident in their responses. All participants used the strategy of differentiation for their students by offering classwork in different ways. P1 stated, “It really depends on what we are doing. Chromebooks are already assigned to a seat. When they sit at a seat, they use that Chromebook to access Google Classroom for their lessons.” P2 stated, “I use Google Slides for note taking. I also use Achieve. The students can read an article and take a test on a science related topic.” P3 indicated, “I use different variations. I do different things. A typical unit would be an introductory lab to explore information, then a lecture and a lab.” P4 affirmed, “we use Google Classroom with our Google Chromebooks. I use Nearpod, Socrative, and Google Tools.” Participant 5 stated, “I show videos and I conduct virtual labs.” The results indicated that the strategies the teachers used increased the understanding of scientific inquiry skills with students. The students were able to apply real world tasks, and personalized learning to better understand science content and skills.

RQ2 results revealed that different technological tools are used to teach scientific inquiry skills. Middle school science teachers used laptops, tablets, calculators, scales, stopwatches, triple beam balance scales, rulers, probes, and a variety of other scientific equipment to teach scientific inquiry skills in the classroom. All technological tools were noted in the materials section of the lesson plan. P3 stated, “We use temperature probes in class as well as iPads or Chromebooks.” Software is also an important aspect of technology that is used in the classroom. The participants prefer to use a file-sharing software like Google Classroom to disseminate information to students. P1 stated, “I post all of my lessons and activities online in our Google Classroom. Students log in and complete the activity.” They also use different online websites. P4 stated, “We use Nearpod for interactive lessons.”

The participants felt they were competent in their technology knowledge after they were trained to use different technological tools. Each participant was a part of the technology cohort at their school and received training to use Google Chromebooks and Apple iPads. P2 stated, “I first began using technology in 2003 in my first year of teaching. I was at a technology school and a part of a cohort of teachers who received training for laptops, and LCD projects to use in class.” P5 stated, “After the technology training, I felt better about using my iPads with the students. I became better with them.” The results indicated that the teachers were competent using technology to teach and having students use technology to complete their activities in class. The teachers used different software programs and a variety of technology to engage student learning. The teachers all used Google Classroom as an information portal for students and blended technology into their classroom activities.

RQ3 results revealed that middle school science teachers felt they were competent in their pedagogical knowledge to use the technological tools and strategies they adopted to cover content prior to the COVID-19 Pandemic. P5 stated, “before Covid-19, I taught PBL in the classroom. The students collaborated together on projects and used computers for research. Now, they are prepared because they have to do it independently at home.” Participants created effective teaching and learning environments for their students. P1 stated, that “when you give clear instructions, it makes gathering data easier, and helps with a more cohesive lesson.” The lesson plans listed clear instructions for the students to complete their assignments. The lesson plans listed the online websites, the tools needed to complete the work, and the assessment, which the teachers posted in the Google Classroom. The participants expanded on their content knowledge with lessons that met the objective and incorporated the use of technology. P4 stated, “Now we create lessons with exclusive online content because of COVID-19. I make sure students are able to learn the content 100% with the technology. Everything is now online” The results indicated that pedagogical knowledge was consistently applied before and during the COVID-19 Pandemic. The teachers were confident they were using the necessary skills to engage students with content to increase their knowledge of science.

According to the results that emerged from the study in RQ4, some negative factors related to the use of technological tools and strategies when teaching science in the middle school classroom were revealed. Middle school science teachers felt too much technology exposure with students was a negative aspect of technology use. P1, P2, P3, P4, and P5 all agree that overuse of technology can be "damaging" to student engagement with technology. P3 and P4 spoke about "using full technology", and that it can be difficult to have students engaged at all times. Both participants said it was challenging. The lesson plans had timing listed for each step of the instruction. The teachers listed how long a student should spend at each stage of the lesson. P5 spoke about the challenges keeping student engaged with technology. P5 has been teaching less than five years and tried to use technology daily despite classroom management concerns. P5 recounted that students "do not want to do the assignments sometimes. They abuse technology and try to opt-out of work." The results indicated that technology was useful but not always easy to engage with students. P5 also stated, "The students can become less complacent with using technology and are less willing to complete their work with technology."

As learning was moved online, another negative factor was that teachers were unsure about whether students understood the scientific inquiry skills. Students had to use whatever technological tools they had at home to complete classwork. P1 discussed the challenges with teaching in an online environment, "students are losing focus. I struggle with getting them to complete work. Some students are not logging online. There was no accountability at home for some students." P2 and P4 agreed, adding, "parents are not holding students accountable." P3 and P5 discussed a different point of view, recalling that "parents are not traditional teachers and they have been thrust into the role of educator with no training on content, technology, or pedagogy. Online learning is not as efficient as face-to-face."

Additionally, the results from the research study revealed some positive factors related to the use of technological tools and strategies when teaching science in the middle school classroom. All 5 participants agreed that the main positive factor was "individualized learning for students." The positive aspect of using technology in the middle school science classroom was that teachers differentiate with students. The participants discussed their progress with student learning and technology usage. P4 recalled "being able to gauge a student's understanding because you are physically present with them. It was easier to interact and know if a student has grasped the concept when you can see their face." P5 acknowledged, "it's great to use technology as a whole class and troubleshoot with students as they worked. It was simpler to handle issues with technology when you have the device in front of you to see the issues." P3 discussed, "hands-on strategies with students and being able to demo activities with the students. Students received immediate feedback on their work effort and skillset." P2 described a typical day with students as "picking up their iPad when they come into the classroom. Students then begin their classwork for the day, which is in the Google Classroom. As they work, I can circulate around and help them complete their notes, graphing, and explanations." P1 articulated the "comfort with being in front of the students as they are taught. There is a nostalgic feeling of that direct communication when I see my students."

**Precoronavirus Pandemic versus Postcoronavirus Pandemic**

According to the participants' perceptions that emerged from the study, student engagement changed during the coronavirus pandemic (see Table 5). The study

Table 5

*Student Engagement with Technology*

| Participants | Student engagement before coronavirus pandemic (%) | Student engagement during coronavirus pandemic (%) |
|---|---|---|
| P1 | 90 | 60 |
| P2 | 95 | 75 |
| P3 | 100 | 80 |
| P4 | 100 | 80 |
| P5 | 80 | 70 |

results presented information that gave an overview of teaching strategies used before the coronavirus pandemic and after the pandemic happened during the school closures. Teaching Strategies that were used prior to the pandemic were no longer used. Before the Pandemic, learning was presented face-to-face with teachers in the classroom with their students. P5 stated, "Before COVID, we did Project-Based Learning. Students were able to collaborate on projects together, use the computers for research, and then present to the class."

All participants agreed that the pandemic has changed education going forward. The participants reported that their adjustment to a virtual environment was still ongoing. Before the coronavirus pandemic, all participants noted that technology was not used daily, but when it was used, students were engaged because the technology was limited in the classroom. The participants stated that now technology was used daily, and students may not be as engaged because all learning, in multiple subjects, were online. P3 stated,

> Using it every day, they get burned out. I do not use technology every day. I don't want my students to take it for granted. Kids crave personal attention. That is hard because everybody has technology. Daily online learning may be overwhelming to students.

Discrepant cases existed when P1, P2, P3, and P4 agreed that data collection was a skill they taught more often than others but, P5 did not. I asked the participants to elaborate more. P3 stated, "I teach a Pendulum Lab where students use a stopwatch to collect data by recording the number of swings from the pendulum in 30 seconds." P2 stated "Gathering data is more easily manipulated with technology." P5 did not agree and contradicted their response. P5 stated, that "data collection is not easy for my students. Research is used more in my classroom to create projects. My students love it." The responses revealed the teachers' have the ability to use technology as an innovative instructional technique. The differences were centered around their technology use and objectives to teach.

The data revealed that the participants believed technology was a useful tool to teach scientific inquiry in the classroom. Participants used strategies such as authentic learning (online publishing, podcasts and videos) and project-based learning (student choice, differentiation) to teach. The technology tools that were used consisted of hardware such as Google Chromebooks, Apple iPads, and scientific lab equipment. The software used was Adobe Flash Player, Google Classroom, and various websites. Peripherals like a computer mouse and earbuds were available when needed. Teacher competency revealed that pedagogy was blended with content knowledge to teach students. The participants were comfortable teaching scientific inquiry skills with technology, tapping into their extensive knowledge about the subject matter. The positive factors that arose from using technology to teach scientific inquiry skills were using specific software, like Google, that offered a suite of products. Digital websites like YouTube, Vimeo, and educational games like Kahoot were useful to engage students and offer enrichment to the lesson. The negative factors that were revealed were the use of the iPads for learning. The iPads were difficult to use with peripherals, like a computer mouse. Students could also become bored and disengage from technology due to overuse. Students were able to differentiate the lesson for the students, having the students perform better. The recent coronavirus pandemic changed this blended approach, and all teaching and learning became virtual. eLearning or virtual learning increased the amount of technology use with students, prompting some positive and negative factors. Pedagogy was essential during this time because classroom management was virtual, and teachers had to rely on their skills to impart knowledge to students.

## Summary

The results of this research study confirmed that middle school science teachers successfully used different strategies with technology to teach scientific inquiry skills. Middle school science teachers used Authentic Learning and PBL strategies to teach science in the middle school classroom. The technological tools that middle school science teachers used to teach scientific inquiry skills were laptops, tablets, calculators, scales, stopwatches, and a variety of scientific equipment. They prefer to use a file-sharing software like Google Classroom to disseminate information to students on devices like Google Chromebooks.

The teachers felt they were quite competent in their pedagogical knowledge to use the technological tools they had been trained to use. They used those tools in the classroom with science content for optimum learning. They used pedagogical knowledge to make learning more efficient. They also felt there were positive and negative factors with using technology in the classroom. The negative factors involved technology overuse with students, and technology not working properly. The positive factors involved using technology to differentiate with students, therefore creating a personalized learning experience.

In Chapter 5, I reiterate the purpose and nature of this research study. I summarize the key findings of the research study. I describe the findings and how they relate to the literature. I analyze the findings and share how they relate to TPACK and relevant literature. The limitations of trustworthiness are described. Recommendations for further research are made, and implications for positive social change are described. The methodological implications are described, and recommendations for social change are given. The chapter ends with a message that captured the essence of the research study.

# Chapter 5: Discussion, Conclusions, and Recommendations

This qualitative case study investigated the best practices used by teachers with technology to teach scientific inquiry skills in middle school science classrooms. While technology tools have been used, little was known about which devices students learned from the best or which devices teachers preferred to use.

To reiterate, the research questions were:

RQ 1: What strategies do middle school science teachers adopt when using technology to teach science in the middle school classroom?

RQ 2: What are the technological tools that middle school science teachers use to teach scientific inquiry skills, and which of these tools do teachers perceive to be more meaningful?

RQ 3: Do the teachers feel that they are quite competent in their pedagogical knowledge to use the technological tools and strategies they adopt to cover the content that is used in the middle school classroom?

RQ 4: What are the negative and positive factors that are related to their usage of technological tools and strategies when teaching science in the middle school classroom?

The findings of this qualitative case study confirmed that middle school science teachers successfully used different strategies with technology to teach scientific inquiry skills. Middle school science teachers have preferences for specific technologies and software. Technology can foster a negative attitude for students when it is overused with students. Technology can foster a positive attitude for students when it is used in different ways with students.

## Interpretation of the Findings

The findings related to RQ1 revealed that, in alignment with the literature, middle school science teachers used different strategies with technology, such as authentic learning and project-based learning, to teach scientific inquiry skills. For example, Williams et al., (2017) and Bippert, (2019) confirmed that teachers used real-world, innovative technological techniques with students to engage them in the curriculum. In Williams et al.'s, (2017) research, they discussed students (a) using flip camera technology to make movies about news stories, (b) using search engines like Google, (c) using presentation software on mini-computers and (d) using tablets to create projects. Students also used collaborative online tools, like Wallwisher, to share and edit information (Williams et al., 2017). According to Bippert, (2019), students gained a sense of ownership and pride in their academics.

The findings of this study confirmed that, to teach, the participants also used real-world technological techniques, differentiation, and projects. Real-world situations were discussed daily in their classroom for students to understand the content. Students used the Internet on Google Chromebooks and Apple iPads to research information for projects assigned as a group and individually.

The findings from RQ2 contradicted the research. According to Hilton (2016), Tokmak (2015), and Minshew and Anderson (2015), iPads were used successfully to teach content to students. In their studies, preloaded apps on the iPads were used mainly to complete preassigned activities. Students were not allowed to go to websites that were not assigned. In my research study, however, the participants did not find iPads useful to teach scientific inquiry skills to students. According to the participants, the iPads'preloaded apps were useful only for teaching science content. The iPads lacked specific software that was critical for using online simulations and online labs to teach scientific inquiry skills. This software was found on the Google Chromebooks, but not the Apple iPads. Unfortunately, there were not enough laptops available for all students to have one in the school.

In my study, the participants used different hardware like laptops, tablets, calculators, scales, stopwatches, along with a variety of scientific equipment to teach scientific inquiry skills. A file-sharing software, Google Classroom, was used by all participants to post their content, materials needed, and activities for students to complete. Peripherals like computer mice and headphones were available for use if a student needed them. According to the study from Tokmak, 2015, laptops were used successfully in the classroom with students. The teachers used them to design educational computer games based on their curriculum, and students were able to use the laptops to complete the educational computer games. In my study, Google Chromebooks were used by teachers successfully to teach content. The Google Chromebook used specific software to access interactive websites for learning. They also used Adobe Flash Player software that enabled more online lab simulations, and software to be accessed at school.

The findings that emerged from RQ3 confirmed teacher competency depends on their content and pedagogy knowledge. The research of Yuksel, (2019) revealed that participants used pedagogical knowledge to incorporate technology into their content. It was noted in their lesson plans, that proper planning and preparation would benefit their teaching. As Padmavathi, (2016) and Tondeur et al., (2016) pointed out, pedagogy influenced how teachers used technology to teach content. In their studies, teachers had traditional teacher pedagogy knowledge to integrate technology into their content. Teachers were responsible for learning their content knowledge, learning the technology, and using their pedagogy to teach and maintain their classroom. In my study, the participants also had suitable pedagogical and content knowledge. With this knowledge, they were able to incorporate technology into their lessons to effectively teach scientific inquiry skills. They used pedagogy to teach scientific inquiry skills with technology. They also planned their activities in their lesson plans, listed the needed materials, and executed their lessons accordingly.

According to the findings that emerged from RQ 4, it was confirmed that negative and positive factors can arise from technology use in the classroom. Weinthrop et al., (2016) discussed how students would no longer engage in different technological programs when they have mastered it. In my study, student academic performance was dependent upon the student’s perspective on technology. The participants referred to how bored the students became with technology. They rushed through their work, to turn off the technology, thus lowering their academic performance. Another negative factor was the participants did not have a strong technology learning knowledge base. They attended one technology training when they first began to use technology in the classroom, but no additional training was offered afterwards. They lacked the needed support for essential training to increase their technology knowledge base. Garba et al., (2015) confirmed that teachers needed training to use different technologies. There was a lack of available technological tools for training, and connectivity issues were problematic. The teachers were in underprivileged economic, rural areas, and Internet connectivity was not stable. The teachers were willing to learn but did not have the needed support or capabilities.

There were also some positive factors that emerged from this study that confirmed the findings in the literature. For example, in the study of McKnight et al., (2016), the teachers differentiated with technology to teach students. They used word processing software, emails, and different Internet websites with students. They also used real-time feedback, such as checking and grading homework as soon as it was submitted, to further tailor a student's academic progress. In my study, it was surmised that the participant teachers were comfortable differentiating instruction and using technology effectively. The participants differentiated instruction with students by also using technology to teach students. They assigned online word processing software for students to create presentations and documents. They also created enrichment opportunities by assigning different interactive science websites with students.

Since starting this research, the COVID-19 pandemic suddenly changed the way teachers were teaching, and all learning moved to an online setting for the remainder of the school year. However, students and teachers were not prepared to move to a virtual environment. Some teachers, like the participant teachers in this research study, had to adjust to a 100% virtual environment to teach. Virtual learning increased during the pandemic. Science requires a hands-on component that is not being achieved during this time because physical learning is limited (Mineo, 2020). Technology changed from being used as a tool, to becoming the primary mode of teaching and learning for students, as seen in Table 5 in Chapter 4.

**Limitations of the Study**

The research study was limited to two schools and five teachers. The study was initially planned for one school with ten participants. Due to the COVID-19 pandemic, volunteers were limited. I only received responses from 3 out of 11 teachers who were identified and contacted. After receiving permission from my committee members, another school was contacted for volunteers to participate in the research study. From the second middle school, I only received 2 out of 8 responses. I again contacted my committee members for guidance and gained permission to continue with five participants. Another limitation was the technology used in this research study. Within the two schools, technology was limited to predominately Apple iPads and Google Chromebooks. The participants had mixed feelings about using these technological tools to teach due to the functionality of the tools.

The participants were at home during the teleconference interview. Since this teleconference interview was in a different state and time zone, I was unable to note body language and other physical nuisances from the participants. Each participant was in their own home and could not be influenced from other participants in the study. As a former science teacher, my personal experience teaching science and using technology did not impact how the data were reported. I accurately recorded and decoded the data, using a data collection template to keep all responses orderly and maintained. I kept a reflective journal to avoid blending my thoughts with the responses of the participants and accurately record them.

## Recommendations

Based on the findings that emerged from my study, it would be essential to conduct more studies with more participants. This research study only had five participants, and the information derived was limited. The recommendation to conduct this research study with more participants could deliver more detailed information for the case study. Having more detailed information could increase the richness of the data, adding more quotes and viewpoints to the research.

Also, it could be recommended that in future studies, the researchers should adhere to better ways of collecting data without resorting to online data collection, and face-to-face interviews must be adopted. Using face-to-face interviews as a data collection method would offer another facet of data, like body language and other nuances. This data could offer another layer of information about the participants, like behavior.

Another recommendation was that more studies should be conducted using a large group of participants from different backgrounds. Teachers from different backgrounds may feel differently about using technology to teach and may use different technological devices other than iPads and Chromebooks. This information could result in cultural, ethnic, or religious differences about technology use.

Future research may investigate technology as a tool and as a means for instruction as more schools and instruction go online. The COVID-19 pandemic has been extremely hard for educators. The traditional way of teaching changed overnight when schools suddenly closed. More research could be conducted about how technology knowledge would be an important aspect of teacher education and a possible criterion for certification. Teachers would need to have a more advanced technology knowledge to teach in a classroom.

## Implications for Positive Social Change

This research study contributes information to help teachers learn more about how to use technology more meaningfully. Teachers gain information about which technological tools and software are helpful in teaching scientific inquiry skills. This research study could be shared with other school districts to assist with creating meaningful science and technology lesson plans and content. On a national scale, the results of this research study can be shared with the National Common Core Science Standards website to add as a resource for strategies, technology tools, pedagogy knowledge, content knowledge, and positive and negative factors utilizing technology to teach scientific inquiry skills. Sharing the findings of the study with other schools would help those schools to improve their science instruction, which leads to social change. Since it was found that teachers had very limited knowledge of some aspects of technologies that could be used in the classroom, organizing more training camps for the teachers would lead to more important social changes within the classroom. It is strongly recommended that more opportunities be provided for teachers to have proper methodological training so that they are equipped to handle technology more effectively.

Technology is at the forefront of education in the 21st century. Technology is used in public and private schools from K-12 education to colleges and universities. Positive social change can be achieved when information is shared between teachers, schools, and school districts. If the strategies and technological tools that are used to teach scientific inquiry skills are shared, science education will continue to grow exponentially. The use of various technological tools could lead to investing and sustaining different technologies by the school. If teachers had access to training to use different types of technology, they could have the ability to use those technologies to differentiate with more ~~with~~ students in the classroom. Pedagogy knowledge, content knowledge, and positive and negative factors are shared with others to show them how to teach scientific inquiry skills in the middle school classroom.

Teaching practices have altered as teachers continue to adapt to new changes due to the COVID-19 pandemic. New scientific discoveries happen daily, almost as much as new technologies are created. As teachers look to their future in the classroom, they want to know that their contributions to the field of science education matter. They want support, training, and technology to assist with their best efforts to teach. Technology has the potential to enhance education and build better relationships between teachers, students, the community, and the world.

Teachers have expressed differences when using technology in face-to-face settings in the classroom. Students used less technology in a face-to-face setting because science was more hands-on. Teachers were able to build strong relationships with students. Academics were consistent. Social interactions were more prevalent between students. The limitations with technology were not as great because technology was used as a supporting tool.

Teachers have also expressed the limitations of using technology daily in a virtual setting. They miss the face-to-face interactions with their students. The virtual interactions do not allow teachers to build strong relationships with their students. Students are not growing academically, socially, or behaviorally like they normally would during a regular school day. The COVID-19 pandemic has truly interrupted the world of the classroom.

## Conclusion

Technology and science are always evolving and changing. This research study gathered information about technological tools that could be adopted to teach scientific inquiry skills in middle school science classrooms. Problem Based Learning and Authentic Learning were two strategies that were used successfully in this research study to teach scientific inquiry skills. Real-world applications and projects were also used to teach science in the middle school classroom. The technology used by teachers helped to create documents, charts, graphs, and solve problems. Google Chromebooks and Apple iPads were used with students, but Google Chromebooks were preferred based upon software compatibility with interactive websites. The technology required for teaching scientific inquiry skills may be different from that for teaching content.

Pedagogy and content knowledge are needed for the successful integration of technology into the classroom. The teachers knew their content and successfully taught it while managing students in-person and virtually, thus proving that technology was no longer a tool for enrichment; it was used as a part of everyday teaching and learning online. One positive aspect of using technology to teach was that learning became enhanced in the classroom, thus providing collaboration among students and providing opportunities for authentic and project-based learning. One negative aspect was that learning could become mechanical and social skills become poor because of technology overuse, and a lack of social interactions with others.

Teachers are at the forefront of science education. Teaching scientific inquiry skills is an important part of learning how to navigate the environment. Teachers need support and access to technology that can jumpstart the workings of young scientific minds; and teaching with technology can make the difference between a student that loves science or hates science. This study is essential to the field of science education and educational technology because the information shared can help science teachers become efficient at selecting and using preeminent technologies to teach scientific inquiry skills in the classroom.

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Appendix A: Interview Protocol

## Interview Research Questions Protocol

Good (morning/afternoon) Mr./Ms./Mrs./ _______________ How are you today?

Thank you for agreeing to participate in this research study on exploring the best practices that middle school science teachers use with technological tools that could be adopted to teach scientific inquiry skills in the middle school science classroom.

I would like to remind you of the Voluntary Nature of the Study from the consent form: This study is voluntary. You are free to accept or turn down the invitation. No one at Walden University will treat you differently if you decide not to be in the study. If you decide to be in the study now, you can still change your mind later. You may stop at any time.

This interview should take no longer than 30 minutes. The interview will be recorded for the purpose of recording, transcribing and analyzing your responses only. Please answer as honestly and openly as you can. Are there any questions before we begin?

| **Interview Questions** | **Response** |
|---|---|
| Research Question 1 | |
| 1. My assumption is that you have been using technology in your science classroom. Can you explain when you first began to use technology in your science classroom? | |
| 2. What type of technology do you use? Can you give an example? | |
| 3. Can you tell me why you chose these particular technologies? | |
| 4. Does these selected technology helps you to improve the content knowledge? Can you explain it in detail? | |
| 5. Can you discuss how you use technology in your science classroom? | |

| | |
|---|---|
| 6. What are the student reactions when you use each of these technological tools? | |
| 7. Have you got the facilities in the classroom which enables you to use these more meaningfully? | |
| Research Question 2 | |
| 1. What technological tools do you have access to in your school? | |
| 2. What technological tools do you have access to in your school? | |
| 3. Can you name some of these tools you use? | |
| 4. Can you link these to content knowledge and describe how you link them? | |
| 5. Do you feel that all the students benefit equally from the use of these technological tools? | |
| 6. Are there any specific tools that you prefer to use? If so why? | |
| 7. Which technological tools do you have in your science classroom? Do you use them? | |
| Research Question 3 | |
| 1. Have you used technology to teach a scientific inquiry standard and how long have you been using technology to teach scientific inquiry standards? | |
| 2. What scientific inquiry standards have you found easier to integrate technology into the lesson with? | |

| | |
|---|---|
| 3. How did you utilize technology without taking away from your teaching style? | |
| 4. Can you describe how you used technology to teach a scientific inquiry standard? | |
| 5. What are some examples of the technologies you used and how? | |
| 6. Which technological tool(s) do you perceive to be more effective to teach scientific inquiry? | |
| 7. Why do you think those technological tools are effective and do you think they should be sustained by your school? | |
| Research Question 4 | |
| 1. What are the negative and positive factors that are related to technology usage in the classroom? | |
| 2. Which technological tools do you think have a positive impact in the classroom? | |
| 3. Which technological tools do you think have less impact in the classroom? | |
| 4. What intrigues you the most about that technology? | |
| **Demographic Information Questions** | |
| How long have you been teaching the subject of science? | |
| How long have you taught the subject of science? | |

| | |
|---|---|
| | |
| How long have you taught science at this school? | |

**Optional Follow-up Question**
Can we go back to what you said about ________ and explain some more?

**End the interview:**
Thank you again Mr./Ms./Mrs./ ________________ for your willingness to participate in this research study. Your responses will be kept secure and your information will only be used for the purpose of this research study. Your $10.00 Amazon e-gift card will be emailed to (verify email address) within three business days.

# Appendix B: Interview Questions

| Research Questions | Interview Questions |
| --- | --- |
| R1: What strategies do middle school science teachers adopt when using technology to teach science in the middle school classroom? | 1. My assumption is that you have been using technology in your science classroom. Can you explain when you first began to use technology in your science classroom?<br>2. What type of technology do you use? Can you give an example?<br>3. Can you tell me why you chose these particular technologies?<br>4. Does these selected technology helps you to improve the content knowledge? Can you explain it in detail?<br>5. Can you discuss how you use technology in your science classroom?<br>6. What are the student reactions when you use each of these technological tools?<br>7. Have you got the facilities in the classroom which enables you to use these more meaningfully? |
| R2: What are the technological tools that middle school science teachers use to teach scientific inquiry and which of these tools do teachers perceive to be more effective? | 1. What technological tools do you have access to in your school?<br>2. Can you name some of these tools you use?<br>3. Can you link these to content knowledge and describe how you link them?<br>4. Do you feel that all the students benefit equally from the use of these technological tools?<br>5. Are there any specific tools that you prefer to use? If so why?<br>6. Which technological tools do you have in your science classroom? Do you use them? |

| | |
|---|---|
| R3: Do the teachers feel that they are quite competent in their pedagogical knowledge to use the technological tools and strategies they adopt to cover up the content that is used in the middle school classroom? | 1. Have you used technology to teach a scientific inquiry standard and how long have you been using technology to teach scientific inquiry standards?<br>2. What scientific inquiry standards have you found easier to integrate technology into the lesson with?<br>3. How did you utilize technology without taking away from your teaching style?<br>4. Can you describe how you used technology to teach a scientific inquiry standard?<br>5. What are some examples of the technologies you used and how?<br>6. Which technological tool(s) do you perceive to be more effective to teach scientific inquiry?<br>7. Why do you think those technological tools are effective and do you think they should be sustained by your school? |
| R4: What are the negative and positive factors that are related to their usage of technological tools and strategies when teaching science in the middle school classroom? | 1. What are the negative and positive factors that are related to technology usage in the classroom?<br>2. Which technological tools do you think have a positive impact in the classroom?<br>3. Which technological tools do you think have less impact in the classroom?<br>4. What intrigues you the most about that technology? |

Appendix C: Interview Codebook

| **Interviewee** | **Interview Question** | **Response: Scientific Content** | **Response: Technology-Rich** | **Response: Teaching Strategy** | **General Response** |
|---|---|---|---|---|---|
| **Participant 1** | Do you use technology in your science classroom? | | | | **3 years** |
| | | | | | |
| | | | | | |

# Appendix D: Follow-Up Email

Good (morning/afternoon) Mr./Ms./Mrs./ _______________ How are you today?

Thank you for agreeing to participate in this research study on exploring the best practices that middle school science teachers use with technological tools that could be adopted to teach scientific inquiry skills in the middle school science classroom.

I would like to remind you of the Voluntary Nature of the Study from the consent form: This study is voluntary. You are free to accept or turn down the invitation. No one at Walden University will treat you differently if you decide not to be in the study. If you decide to be in the study now, you can still change your mind later. You may stop at any time.

Thank you for agreeing to answer some follow-up questions concerning your original responses for this research study. The following questions should take no longer than 30 minutes to answer. Please answer as honestly and openly as you can. Please email your responses back to me.

Q1: Can you describe how you use technology to teach scientific inquiry skills?
Q2: Are there any specific technological tools that you favor in your classroom and why?
Q3: How did they use technology without taking away from their teaching style?
Q4: What intrigues you most about technology?

Thank you,

Victoria R. Gamble
Doctoral Candidate
Walden University 2020

Appendix E: Lesson Plan Codebook

| Four aspects included in the lesson plan | Questions used when evaluating the lesson plan | Relationship to the research questions |
|---|---|---|
| Objectives | Does the objectives embedded in the lesson plan show any evidence of the use of technological tools? | |
| Focused questions | Does the questions included in the lesson plan show that different strategies are used by the teachers during the lesson? | |
| Procedures | Does the procedures adopted by the teachers when developing the lesson show that technological tools are used by the teachers during the lesson? | |
| Assessment | Does the assessment system adopted show any indication that the students are encouraged to use technology? | |