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Implementation of International Society for Technology in Education Standards in Elementary School Teachers’ Pedagogical Science Practices

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This is to certify that the doctoral dissertation by

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Walden University
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Abstract

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MA, Western Governors University, 2012

BS, Western Governors University, 2006

Dissertation Submitted in Partial Fulfillment

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Abstract

This study addressed the problem of whether elementary school teachers are consistently implementing the International Society for Technology in Education (ISTE) standards in their pedagogical practices of teaching science. It was evident that half of all teachers in the United States do not consistently implement technology into their instruction. The purpose of this study was to understand elementary school teachers' perceptions about how teachers are using the three selected ISTE standards during their pedagogical practices when teaching elementary science in order to maximize learning. The technology acceptance model was the conceptual framework used in this study. The research questions focused on the perceptions of teachers pertaining to the implementation of the selected ISTE standards to maximize student learning in science and how they are innovating their science instruction. The study was conducted within the general qualitative framework because elementary school teacher perceptions were the basis for the study. Data were collected through individual interviews with a selected sample of 11 teachers and a review of their lesson plans. Interviews were conducted and coded for common emergent themes. The findings indicated that the participants found the select ISTE standards to be essential when teaching science as well as many innovative practices to maximize student learning. Participants also shared the resources necessary to implement the innovative technology to maximize student learning. Understanding what technologies teachers perceive to be useful and innovative can improve science instruction methods and promote social change for students, schools, and communities by maximizing student science achievement.

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Dedication

I would like to dedicate this page to my boys and some amazing women in my life. Logan and Joseph, you both are my rock and my life. Remember, you can do anything you set your hearts and minds to. Every time I felt like giving up, I would think of you both, and you gave me the strength I needed to continue. Thank you for believing in me and being the best sons a mother could ever ask for. To the two most incredible women in my life, my mom, Leslie, and twin sister, Mariah, aka partners-in-crime. Both of you have shown me what true strength is and how to overcome the toughest life has to throw at us. I admire both of your independence and perseverance and looked to it daily while going through my dissertation. Thank you for always being there. To my second mom for the last 40 years. Mary, thank you for your never-ending belief and support, even on the days when I didn't believe I would succeed. Without these special people in my life, this accomplishment would not have been possible. Therefore, I would like to share this once in a lifetime moment and achievement with you.

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I would like to acknowledge my dissertation committee, Dr. Loren Naffziger and Dr. Asoka Jayasena, for believing in me and pushing me to be the best I could be during this dissertation journey. Dr. Naffziger, you talked me off many cliffs, and your patient and wise guidance will never be forgotten. You always knew just what to say and how to help me to grow in my journey. Dr. Jayasena, you pushed me to limits even I did not know were possible. You both challenged me to become the scholar I only dreamed of becoming one day. I could not have completed this journey without the never-ending support you both have given me over the last two years. Thank you sincerely and I look forward to joining the ranks with you.

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Chapter 1: Introduction to the Study

Currently, technology has become an integral and essential aspect of student learning in school settings (Gomez-Arizago et al., 2016; Tastan et al., 2018). Although research and attempts to integrate technology into education are being made, considerable improvements need to occur, especially in science education (U.S Department of Education [USDE], 2017; Wyoming Department of Education [WYDOE], 2017). The lack of science achievement is still a problem not only in the state of Wyoming, but also in the whole country (NAEP, 2015). Internationally, the United States ranks 25th in science achievement (Organisation for Economic Co-operation and Development [OECD], 2016). Since it is established that technology use is critical to improve science instruction (Fokides & Atsikpasi, 2016), understanding how technology is integrated effectively can help others to be able to use technology to increase effective science instruction.

In this chapter, I provide information about the importance of the study, the problem statement, the purpose of the study, and research questions. The chapter also includes the conceptual framework, nature of the study, and definition of terms needed to understand the study better. The scope, assumptions, limitations, and delimitations, and significance of the study are also discussed.

Background

In this study, examining elementary school teachers' needs and their perceptions of when technology is used in their pedagogical practices was critical to understanding how technology is being used during science instruction. While technology has been found to improve student instruction and achievement, many studies have been inconclusive. Therefore, further research is needed to understand better technology integration and the impact it is having on students' science instruction. Innovative technologies are a positive and useful tool in the classroom (Gomez-Arizaga et al., 2016). Technology has also been linked to science achievement and increased student and teacher self-efficacy toward science instruction (Gomez-Arizaga et al., 2016; Tastan et al., 2018). Technology has been linked to many positive outcomes, including increased self-efficacy and achievement (Son et al., 2016). Ensuring teachers use technology consistently could have a positive impact on science achievement as well as on teacher and student attitudes toward science instruction.

Although technology has been linked to student achievement in science, most of the studies (e.g., Gomez-Arizaga et al., 2016; Son et al., 2016; Tastan et al., 2018) have been quantitative in nature. Teachers' perceptions need to be studied to better understand what technology teachers perceive to be effective and are currently using in their science instruction. Since the use of technologies have been shown to have a positive effect on science achievement (Gomez-Arizago et al., 2016; Tastan et al., 2018), understanding what technology teachers perceive to be effective could help fill the current gap in the literature. The International Society for Technology in Education (ISTE) standards were adopted in 2016 by the state of Wyoming. The adoption of these standards was made to benefit the students through increased use of technology in the classroom.

Problem Statement

The problem addressed in this study is whether elementary school teachers are consistently implementing the ISTE standards in their pedagogical practices of teaching science. Teachers, in general, can have difficulty utilizing technology in their instruction. According to the USDE (2017), almost half of all educators in the country are not able to utilize technology consistently and effectively in their instruction. As such, understanding teachers' utilization of technology during science instruction is necessary (DeCoito & Richardson, 2018). Teachers' needs and perceptions concerning technology integration in education need to be studied further and should be a necessary dimension in future studies (Tondeur et al., 2016). While technology can improve student achievement, it is still necessary to determine specific technological and pedagogical strategies that complement technology integration into science instruction (Fokides & Atsikpasi, 2016; Grabau & Ma, 2017).

Due to the adoption of the ISTE standards, technology integration is a viable factor to consider while studying the problem. ISTE standards were adopted in 2016 with the intent to integrate technology into core subject areas (Crompton, 2017). Since it has been established that technology use is critical to improve science instruction (Fokides & Atsikpasi, 2016), a more precise understanding of the role teachers' play in this process is needed. Hence, I conducted this study of teachers' implementation of the ISTE standards to understand how technology is influencing their pedagogical practices. The focus in this study was on 3 of the 28 ISTE standards that were chosen because they are more related to pedagogical practices (ISTE, 2016). The three ISTE standards are:

1. ISTE Student Standard 3: Knowledge Constructor - Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts, and make meaningful learning experiences for themselves and others.
2. ISTE Teacher Standard 5a: Use technology to create, adapt, and personalize learning experiences that foster independent learning and accommodate learners' differences and needs.
3. ISTE Teacher Standard 5b: Design authentic learning activities that align with content area standards and use digital tools and resources to maximize active deep learning.

I chose these three ISTE standards to align with the problem of how elementary school teachers implement the ISTE standards into their pedagogical practices of teaching science. Understanding the variety of digital tool resources students are using, how teachers are personalizing the use of technology for students, and how the technology is being used authentically to maximize student learning will help determine how teachers are using the standards in their pedagogical practices during science instruction. Gathering teacher perceptions can play a critical role in developing an understanding of the pedagogical practices being used involving technology and the effect those practices are having on student learning (Park et al., 2016; Salami et al., 2015).

Purpose of the Study

The purpose of this qualitative study was to understand teacher perceptions of their use of the three selected ISTE standards to maximize student learning during their pedagogical practices when teaching science. I specifically explored the influence that the recently implemented three ISTE standards have had on teachers' pedagogical practices aimed at maximizing student learning. DeCoito and Richardson (2018) discussed student science, technology, engineering, and math (STEM) deficiencies and the need to integrate technology to STEM instruction to address these deficiencies. There is a need to understand the influences occurring during science instruction, primarily with technology (Grabau & Ma, 2017). At two exceptional school districts of focus in this study, students performed above state and national averages in science (WYDOE, 2019). Studying what happened to student test scores since the implementation of the ISTE standards would help to understand whether the implementation was of any benefit to the students (Yoon et al., 2017).

Research Questions

The following central research question and subquestions guided this study:

Central Research Question: What are the perceptions of elementary school teachers pertaining to the implementation of the selected ISTE standards to maximize student learning in science?

Subquestion A: In what ways do elementary school teachers perceive the three selected ISTE standards innovating the teaching of science?

Subquestion B: What are elementary school teachers' perceptions of the needs of elementary teachers when technology is used in science instruction to maximize student learning?

Conceptual Framework

The framework be used for this qualitative study was the technology acceptance model (TAM) theory (see Doulani, 2019). First introduced in 1985, this model can be used to understand the ease of use and perceived usefulness of the integration of technology as well as the user's attitude and acceptance of the technology (Davis, 1985). Davis (1985) stated that the TAM theory is an extension of the Fishbein model (Fishbein & Ajzen, 1980), more publicly known as the theory of reasoned action (TRA). Both the Fishbein model and the TAM theory involve the individual perception of how technology is accepted by the user. Teachers' perceptions of technology can be a predictor of whether technology is accepted and has a positive influence during student instruction (Doulani, 2019).

I chose the TAM theory to frame this study because understanding teachers' acceptance of the new technology implementation and standards is necessary to determine how the teachers are implementing the newly adopted ISTE standards in their pedagogical practices. The selected rural school districts for the study have not only fully implemented the standards but have also had an increase in student science achievement over the past 3 years. Understanding how these elementary school teachers at the rural school districts are using technology in science instruction could provide support to other educators within the state and nationwide.

Nature of Study

I used a general, qualitative, descriptive design for the study. Qualitative research was necessary to identify how teachers implement the ISTE standards in pedagogical practices of teaching elementary school science. A qualitative descriptive design is explained as describing or defining specific variables or criteria in a simple process, not by analyzing or comparing different variables to one another (Rumrill et al., 2011; Sandelowski, 2010). The participants consisted of 11 elementary teachers drawn from the two research sites. I conducted individual interviews with the selected participants. The interviews allowed the teachers to have a less formal opportunity to describe their perceptions and experiences. Yin (2016) and Rubin and Rubin (2012) noted the importance of conducting interviews in a semistructured, conversational mode. Use of the open-ended questioning technique ensured that participants gave authentic answers (see Rubin & Rubin, 2012). During the interviews, I also collected a copy of recent science lesson plans from the participants to review. Reviewing the lesson plans provided another method of data collection and afforded a more in-depth perspective and history to a program, in this case elementary science instruction (see Mertens, 2020).

Qualitative research consists of five main approaches: case study, phenomenology, ethnography, narrative inquiry, and grounded theory (Creswell & Creswell, 2018). A phenomenology study was considered with the phenomenon being studied the teachers' acceptance of the new ISTE standards in science instruction. Phenomenology is defined as wanting to understand the underlying meaning of a perception or experience (Merriam & Tisdell, 2016). Since the purpose of this study was descriptive in nature and teachers described their practices and perceptions, I considered the general, qualitative, descriptive design a more appropriate choice. Ethnography is used to help the researcher understand a specific culture (Merriam & Tisdell, 2016). I did not choose this design because one particular group or culture of students was not being studied. Narrative inquiry was another consideration for the design of this study. Narrative inquiry uses the stories of others to help better understand life experiences in the world (Merriam & Tisdell, 2016). Patton (2015) explained narrative inquiry as a design used to develop a more in-depth understanding of a shared phenomenology or perception. Since the perceptions are unknown at this point, this design was not a suitable fit for this study. The grounded theory design was the final qualitative design considered for this study. Merriam and Tisdell (2016) described the grounded theory as deductive and comparable in which data are cross-compared to determine common themes and understanding. In this study, I investigated how teachers' perceptions of the implementation of the ISTE standards affect their pedagogical practices of teaching science to maximize student learning. The study specifically explored the influence the implemented and selected ISTE standards have had on successful teachers' pedagogical practices.

Definition of Terms

In this section, I provide definitions of terms essential to the study to eliminate possible confusion or misunderstanding. Acronyms or terms that could have multiple meanings have been defined using the correct definition in context to this study.

Although a term may have more than one definition, only the appropriate definitions to understand this study have been provided.

Educational standards: Shared principles of what students need to know, how students will come to know, and that can provide a basic teaching implication (Wang & Odell, 2002).

ISTE: An organization founded in 1979 that created the first essential conditions for education in 2003, and later the ISTE standards in 2009 and 2016 (ISTE, 2016).

Pedagogical practices: Teaching strategies and ways of providing instruction. (Cohen et al., 1976).

Perceived ease of use: The level of how teachers accept technology depends on whether teachers perceive the technology is easy or more difficult to use (Davis, 1985).

Perceived usefulness: Teachers' perceptions regarding how useful the technology is within instruction can affect a teachers' acceptance of the said technology (Davis, 1985).

TAM Theory: First introduced in 1985, this theory explains how a user goes about accepting technology through three specific ways: perceived ease of use, perceived usefulness, and the user's attitude toward the said technology (Davis, 1985).

Technology integration: The process of facilitating and managing learning through purposeful integration of technology tools into the learning and pedagogical process (Januszewski & Molenda, 2013).

USDE: Established by the U.S. government in 1980, the purpose of this department is to promote student achievement, educational excellence, and global competitiveness (USDE, 2017).

Assumptions

Assumptions can be defined as the researcher's understanding of the object of inquiry (Hatch, 2002). ISTE standards were adopted by Wyoming as a framework for integrating technology into teaching pedagogical practices and student learning. I assumed that since the ISTE standards were adopted in 2016, that the teachers have begun integrating technology into their pedagogical practices. More specifically, I assumed that the technology integration is occurring during science instruction. An additional assumption was that most teachers have a common understanding and awareness of the ISTE standards for teachers and students. My final assumption was that teachers would not make any modifications to their pedagogical practices during the period of data collection.

Scope and Delimitations

The scope of a study is defined as the parameters in which the study will be operating within (Simon & Goes, 2011). The scope of this study was focused on science education at the elementary school level. Within this parameter, I studied elementary school teacher perceptions about the implementation of the three selected ISTE standards to maximize student learning. Even more specifically, I determined how teachers are implementing the ISTE standards within their pedagogical practices during teaching science.

Delimitations are implemented in a study to ensure whether a narrower focus can be achieved (Simon & Goes, 2011). The elementary teachers who provide science instruction consist of a large cohort. Out of this large cohort, I used criterion sampling to select a field of elementary teachers who teach science. The school districts and schools were selected purposefully for inclusion in this study due to their high levels of science achievement over the past 3 years (see WYDOE, 2019). To be able to understand how the three selected ISTE standards are being used effectively, it was essential to select schools that have shown effective science instruction consistently since the implementation of the ISTE standards.

Limitations

Hatch (2002) explained that identifying limitations within a study allows the researcher to monitor those limitations. Data collection was a limitation in this study. Data collection was limited to two rural school districts and based on criterion sampling to schools that have seen a continuous increase in science achievement over the last 3 years. Due to COVID, many of the school districts were unavailable. Population was another possible limitation. The area where the study took place has a population just under 18,000. In the data analysis, I needed to be careful to identify potential bias. Elementary teachers teaching up to sixth grade in the state do not require a minor in science to teach science; consequently, their experiences may vary due to their limited experiences and exposure to knowledge.

Significance of Study

This qualitative study may contribute to the field of education by investigating how elementary school teachers implement the ISTE standards in their pedagogical practices of teaching science to maximize student learning. Furthermore, by examining teachers' implementation of the three selected ISTE standards and their use of technology during science instruction, insights can be gained to determine what more is needed to improve science instruction. Meeting teacher needs to effectively use technology and improving science instruction methods can contribute to positive social change for the students, school, and community. Effective technology implementation during science instruction has been found to increase student engagement and student achievement (Merchant et al., 2014; Suana, 2018).

Summary

Understanding how elementary school teachers' perceptions of the implementation of the ISTE standards affect their pedagogical practices of teaching science is vital to the future and success of science education. Elementary school teachers' perceptions regarding the ease of use of technology and the acceptance of the said technology can impact the levels to which the technology is integrated (Mugo et al., 2017; Teo & Zhou, 2017). The use of technology in science instruction has been found to increase student engagement and improve science achievement in recent studies (Park, 2015; Xia & Zhong, 2018). Examining teachers' needs and perceptions related to the use of technology in their pedagogical practices is critical to understanding how technology is being used during science instruction. The TAM was the framework used for this qualitative study.

The problem addressed in this study was teachers not consistently implementing the ISTE standards in their pedagogical practices of teaching science. Definitions of terms used in the study were provided and assumptions, scope and delimitations, and limitations were also discussed in this chapter. The significance of the study was explained as well as how the findings could improve science instruction methods and promote social change for the students, schools, and community.

In the following chapter, I will present a thorough review of literature regarding science education influences and the integration of technology within those influences, including professional development, certification, teacher self-efficacy, gender, student self-efficacy and motivation, inquiry-based instruction, outreach activities, problem-based learning, science literacy, dual-language instruction, Nature of Science (NOS), and classroom level assessment models.

Chapter 2: Literature Review

The purpose of this chapter is to provide a comprehensive review of literature related to technology in science instruction that has been applied in elementary schools. I explain the search terms used to locate literature for the review, the theoretical foundation for the research, and the TAM (see Davis, 1985). The literature review also includes a synthesis of literature on the ISTE standards; technology in science education; and factors influencing science education with and without the use of technology, including professional development, certification, teacher self-efficacy, gender, student self-efficacy and motivation, inquiry-based instruction, outreach activities, problem-based learning, science literacy, dual-language instruction, NOS, and classroom level assessment models. With each of the factors that have influenced science instruction, I identify how technology, when applicable, has influenced each contribution to science instruction. A history of science on a global level, in the United States, in the selected state, and the history of ISTE standards are also provided. To conclude the chapter, there is a summary of the literature reviewed.

Based upon the recent adoption of the ISTE standards, there is a lack of research related to elementary school teacher perceptions about how they use the selected ISTE standards to maximize student learning during their pedagogical practices when teaching science. Understanding teachers' needs and perceptions as to when technology integration is successful and what is needed is necessary (Tondeur et al., 2016). In a review of the literature, Liu et al. (2018) concluded that many studies were inconclusive on whether technology was a positive influence on student science achievement. This lack of research supports the need to study the research problem since teachers do not consistently implement ISTE standards in their pedagogical practices of teaching science. According to the USDE (2017), almost half of all educators are not able to utilize technology consistently and effectively in their instruction. To gain a full understanding of the progress of science education, it is important to understand all factors that have contributed to its development.

Literacy Search Terms

I used many different search terms and strategies to locate scholarly, peer-reviewed journal articles for this literature review. The journal articles selected for this review were published within the last 5 years. The databases searched were ERIC, Education Research, EBSCO Host, Academic Search Complete, Education Source, The National Science Foundation, Psychology Databases Combined Search, PsychINFO, and Google Scholar. The search terms used were *literature review* OR *meta-analysis*, *technology acceptance*, *technology integration K-12*, *science education*, *achiev** OR *success*, *elementary* OR *primary*, *teachers* OR *administrat**, *attitudes* OR *perceptions* OR *beliefs*, *student success*, or *academic achievement*, *STEM*, and *K-12*, *technology acceptance model*, *TAM*, and *ISTE*.

Theoretical Framework

TAM theory was the theoretical framework used in this study. First introduced in 1985, the perceived ease of use and perceived usefulness of the technology integrated can determine the overall user attitude and acceptance of the technology (Davis, 1985). Davis (1985) described perceived ease of use as the level of physical and mental effort it takes a user to use a technology. Davis defined perceived usefulness as the user's attitude toward the said technology and the impact it has on the user's job performance. Davis stated the TAM theory is an extension of the Fishbein model (Fishbein & Ajzen, 1980), more publicly known as the TRA. According to the TRA, an individual's actions depend on their preexisting attitudes and behaviors (Fishbein & Ajzen, 1980). By using the TRA framework, Buabeng-Andoh (2018) found that behavior intention had a significant result in determining whether to implement the technology.

I chose the TAM theory as the framework for this study to determine to what level teachers have accepted the ISTE standards into classroom science instruction and what effect they perceive the standards are having on science achievement. I will build upon previous research by studying teacher perceptions concerning the impact the ISTE standards have had on students' academic achievement. I determined teachers' acceptance level and implementation of the ISTE standards to provide a better understanding of technology integration in science instruction. Since ISTE standard integration began in 2015, the framework helped me to understand the integration level of the teachers, the usefulness of the standards, and the perceived influence the standards are having on student science achievement. Many themes in current research involve technology in science education, including STEM education; computer and robotic instruction; and student engagement, which often includes technology (Baturay et al., 2017; Gyamfi, 2017; Ha & Lee, 2019; Teeroovengadum et al., 2017).

Teeroovengadum et al. (2017) studied the integration of technology in a developing country and explored demographic variables as well as the TAM principles of perceived ease of use and perceived usefulness of the technology. They found that although demographic variables did have some effect on technology integration, the variables were insignificant in comparison to the impact of TAM principles on technology integration. When participants viewed ease of use and perceived usefulness positively, the technology integration was effective. In a similar study in South Korea, Ha and Lee (2019) integrated Self-Monitoring Analysis And Reporting Technology (SMART) technology into elementary classrooms and studied teacher perceptions regarding positivity levels when implementing the technology. They found that teachers who had learner-centered views demonstrated a significantly higher acceptance of the SMART technology.

Gyamfi (2017) and Baturay et al. (2017) studied preservice teachers using the TAM as the research framework to explore factors that influence the use of technology during instruction. The two TAM principles are perceived ease of use and perceived usefulness. Gyamfi found that leadership support directly affected the perceived ease of use and job relevance significantly impacted perceived usefulness. Perceived ease of use also was shown to have a direct effect on teachers' attitudes toward using the technology. Baturay et al. found a significant and positive relationship between computer competence, perceived usefulness, perceived ease of use, and attitudes toward the computer-assisted technology. Self-efficacy, an individual's belief in themselves and how well a task can be executed (Bandura, 2001), will be the second theoretical framework applied in the studies above. I used the theoretical framework as a lens through which to understand how teachers' perceptions of the implementation of the ISTE standards influence their pedagogical practices of teaching science.

ISTE Standards

ISTE standards have been adopted by many states in an attempt to provide innovative technology to academic instruction (ISTE, 2016). In 2007, ISTE (2007) developed its first technology standards for learning. The standards were a framework of how technology should be used to support education. In 2016, the current and updated ISTE standards for teachers and students were published. In 2007, the standards were one document, were not separated by educator and student, and had six guiding principles (ISTE, 2007). The six principles were communication and collaboration, creativity and innovation, technology operations, digital citizenship, critical thinking, and research and information. Communication and digital citizenship were the only two principles that were adopted in the updated 2016 standards. The current 2016 standards for students have seven principles: empowered learners, digital citizen, knowledge constructor, innovative designer, computational thinker, creative communicator, and global collaborator.

A few recent studies have focused on the ISTE standards. For example, Dondlinger et al. (2016) conducted a qualitative study to determine if sixth-grade students gained attainment of the ISTE standards through a 1-week math innovative curriculum, Math Out Loud. Students showed significant attainment of the ISTE standards and higher math achievement after the curriculum was taught (Dondlinger et al., 2016). The authors suggested that similar studies should be conducted in other subject disciplines. In a qualitative study, Ayad and Ajrami (2017) found the level of ISTE implementation and knowledge was present for preservice education teachers. Their study indicated that the level of ISTE implementation and understanding was low and implied further implementation and education regarding the ISTE standards be provided. Although one study used students and the other teachers, both studies expressed the importance of implementing the ISTE standards to increase technology in education (Ayad & Ajrami, 2017; Dondlinger et al., 2016). More research is needed to understand current teachers' perceptions of how the ISTE standards are being implemented into instruction, more specifically science instruction.

Technology in Science Education

In a systematic review of recent literature, Tondeur et al. (2016) found that technology integration can only be completely understood when teachers' pedagogical beliefs are understood. Teachers play a key role in the decisions of how to use technology during their instruction. Technology has been part of professional development, robotic instruction, self-efficacy, inquiry-based instruction, engagement, motivation, literacy, dual-language instruction, project-based learning, and gender studies. Further understanding of teachers' needs with technology integration conceptualization, utilizing the technology, and considering the educational purposes surrounding technology integration is necessary (DeCoito & Richardson, 2018).

Factors Influencing Science Instruction With and Without Technology Influence

Many factors have been found to influence science instruction; some of those factors involved technology and some did not. I present both in this literature review to gain a broader understanding of what is influencing science instruction. The professional development and self-efficacy of teachers can affect science instruction both positively and negatively (Kizkapan &Bektas, 2017; Merritt et al., 2017). Self-efficacy, inquiry-based instruction, engagement, motivation, literacy, dual-language instruction, project-based learning, and gender can also influence student science achievement (Cai et al., 2017). Each of the following subsections addresses the factors that influence science instruction.

Professional Development

Professional development implementing technology into science instruction has been found to have positive results, which include more engaging and efficient instruction, increased lesson effectiveness, and an increase in technology use by teachers during science instruction (Blanchard et al., 2016; Hu & Garimella, 2017). During a science instruction professional development, teachers reported an increase in student engagement and efficiency during instruction with the use of technology (Blanchard et al., 2016; Hu & Garimella, 2017). Teachers also reported increased comfort levels with implementing technology during science instruction. Blanchard et al. (2016) found that all teachers continued to implement technology into their science lesson after the professional development; however, Hu and Garimella (2017) found that only 76% of the teachers continued to implement technology following professional development. Further understanding of the reasons for the lack of technology implementation after the training and the needs and perceptions of teachers regarding technology integration could be studied. Professional development involving technology integration during science instruction in rural and high poverty areas has also been studied in recent years (Blanchard et al., 2016).

Professional development has shown improved teaching methods utilizing technology in rural, high poverty student populations. Specifically, African-American middle school level students showed significant growth on end-of-year science and math assessments after teachers completed a 3-year reform-based technology integration professional development program (Blanchard et al., 2016) however researchers have conducted many studies involving teacher professional development and science instruction and researchers also look at non-technology influences (Dailey & Robinson, 2016; Yoon et al., 2017; Zhang et al., 2015). Having a broader understanding of effective influences to science instruction will help provide information to gain teacher perceptions of what is effective or not. The growth in science achievement that Blanchard et al. (2016) reported used quantitative data and teacher perceptions were not studied to determine what specific technology was found effective.

Professional development provides intentional development opportunities for teachers and also forethought to seek out necessary training. Professional development has been examined carefully in recent years to determine concerns that teachers are still having about teaching science. Dailey and Robinson (2016) found that, in professional development, teachers expressed concerns about time, money, efficacy, and knowledge to explain what is required. Zhang et al. (2015) implied the need to develop responsive professional development programs to meet the individualized needs of teachers. In contrast, Yoon et al. (2017) completed an empirical review of science education research from 1995-2015. Student achievement at the classroom-level was found to be higher with professional development, although the studies did not determine which types of professional development specifically promoted student achievement. Even though science achievement has increased, and there have not been studies that exhibit what hinders teacher professional development. No recent studies determine specific professional development components leading to higher student achievement on classroom-level assessments.

Professional development of teachers and self-efficacy can both have a positive impact on student academic achievement. Son et al. (2016) reported that both the United States and South Korea showed marked improvement on student classroom level achievement when teachers' self-efficacy was higher, and teachers had the opportunity to receive effective professional development. McKinnon and Lamberts (2013) showed an 11-month increase in efficacy in 85% of participants who completed four hours of primary school science professional development. When teachers participated in professional development, teachers' self-efficacy was improved, creating a positive impact on student achievement. Many of the studies were quantitative (McKinnon & Lamberts, 2013; Son et al., 2016); therefore, studying teacher perceptions is necessary to understand how teachers accept and apply what they have learned during science instructional practices.

Teachers currently teaching elementary school have also been researched involving the positive and negative effect of professional development and teaching science. Allen and Penuel (2015) found that teachers were apprehensive when it came to available resources, implementation, and unclear instructional goals. Although each school studied had different instructional goals, implementation procedures and resources, apprehensions resembled one another. Professional development can also improve student outcomes in the science classroom setting. According to Egert et al. (2018), a meta-analysis revealed that professional development that focused on attitudes and pragmatic understanding around teaching science yielded higher student outcomes. A need for more extended professional development to increase rigor and deepen understanding exists due to research showing the detriment of professional development too short in length, which can lead to lower student outcomes (Egert et al., 2018).

School leadership can play an important role in teachers' professional development, creating a positive or negative impact on the development of teachers. Whitworth and Chiu (2015) during a qualitative study, picked three areas identified by teachers, which were stronger leadership support, school culture, and teacher motivation about professional development. According to the group of teachers in this study, all three of these areas can result in gains to classroom level student achievement.

With many states and schools adopting the new Next Generation Science Standards (NGSS) training to teach the new standards satisfactorily is valuable. Teachers are identifying the need to correctly understand and teach inquiry-based instruction through professional development opportunities with the new science standards being introduced (Zhang et al., 2015). A contradictory study by Fischer et al. (2018) showed a strong relationship between professional development and the new standards, but an insignificant impact on student achievement and growth on student learning outcomes.

Tuttle et al., (2016) completed a 2-week NGSS professional development and showed growth in science content and inquiry teaching strategies. However, Tuttle et al. did not collect data comparing student achievement in relation to growth in science content.

Teachers depending on how many years of service also seemed to cause variation in response to professional development interests and needs. A review of 74 research studies, showed new teachers and experienced teachers were exposed to the same types of learning activities and professional development opportunities (Kyndt et al., 2016). New teachers were willing to experiment more and showed a more accepting attitude toward new instructional approaches than those teachers who had been teaching longer. Many of the research studies reviewed by Kyndt et al. (2016) involving professional development also do not separate new and experienced teachers and often have a combination of both in each study. Based on the empirical review of research, studies could be skewed based on different interests and attitudes toward teaching science (Kyndt et al., 2016). A weakness in approaches used when trying to determine common themes emerging from the above studies, is that each study used a different type of professional development from one another. Therefore, it is difficult to accurately synthesize the results of the literature, since the variables; in this case, professional development opportunities all vary. In addition to professional development, with and without technology integrated, computer resources and robotic instruction are a recent trend in literature and science instruction.

Many studies viewed teacher perceptions when studying effectiveness of professional development and science instruction with and without technology (Dailey &

Robinson, 2016; Eckhardt, 2018; Zhang et al., 2015). Teachers' perceptions can help understand what specifically is being effective to student science instruction. Therefore, this study will fill in a gap existing in literature about the elementary teachers' perceptions of technology implementation during science instruction.

Robotic and Computer Resources

In recent years, computer-simulated learning has become a trend in classrooms across the United States and the world. Determining the effectiveness of robotic and computer-simulated learning has shown mixed results. Hannel and Cuevas (2018) found that computer-simulated science resources produced similar academic achievement levels as students using physical manipulatives, although the computer simulated resources had a higher positive impact on student self-efficacy than physical manipulatives. Acceptance of the technology was also in question due to the simulation training only being for one day and could have had some effect on the results of the study (Hannel & Cuevas, 2018). Xia and Zhong (2018) conducted a systematic review of recent literature and found that although computer resource learning provides a positive effect on student learning, many studies have been inconclusive regarding the impact on students' science achievement.

For example, Park (2015) found that elementary students in a robot-enhanced learning environment showed more pre/post-test growth in academic achievement and motivation level than students in a control group over 10 weeks. One meta-analysis indicated that most research done on robotic science instruction had been limited to low cognitive level assessment, such as pre/post assessments and not high cognitive level problem-solving assessments (Douglas et al., 2016). A weakness in the study (Douglas et al., 2016) inherent to the approach used is the level at which the students are assessed is not the same level of problem solving required during other measurements of assessment, possibly such as standardized assessment. Technology has also had an impact on preservice certification, both positively and negatively. However, the majority of the studies were quantitative (Douglas et al., 2016; Hannel & Cuevas, 2018; Park, 2015; Xia & Zhong, 2018). Qualitative studies to determine teachers' perceptions of which technology is being most effective during science instruction could be beneficial and is lacking in recent literature.

Certification

Technology courses and technology support preservice teachers receive can vary. Olson et al. (2015) found that many universities required technology courses, whereas other universities did not require any specific courses in technology. In a similar study that also studied preservice teachers' efficacy with technology in the classroom, Sadaf et al. (2015) found that preservice educators felt confident utilizing the technology tools available to use in the classroom, but lacked the resources and support needed to implement the technology. Secondary pre-service teachers have also shown more confidence and understanding toward the value of mobile technology integration during instruction than elementary and middle school teachers possibly due to variance in technology instruction during course work (Kale, 2018). Technology among preservice teachers not only has shown variance in the course work received, but also confidence implementing technology and the value technology has on the student learning. Non-technology requirements for pre-service science teachers have also shown differences.

Each college program and the school districts have different requirements for elementary education certification; more specifically, the education received in teaching elementary science. Preston (2017) found that teachers showed a potential need to receive more educational psychology and adolescent development coursework in the teacher preparation and certification process. Olson et al. (2015) stated that only 26% of middle school teachers have a degree in science, and elementary certification only required biology and physical science, with no requirement for chemistry or physics course. Olson et al. also found that only 42% of elementary certified science teachers felt confident to teach science based on their education level and science content knowledge. Since all states and districts have different requirements for certification and what is required to teach at the elementary and middle school levels, teachers often lack confidence in their ability level to teach the science content needed, including technology integration abilities. Teacher self-efficacy and confidence toward teaching science is not only present in preservice certification studies, but also in existing teacher studies as well.

Teacher Self-Efficacy

Self-efficacy of teachers has been studied to understand effective instruction through the use of technologies and without by examining student achievement without technology being studied. The results of a study by Scherer et al. (2018) showed that the results of teachers' attitudes toward technology by studying technology stand-alone were inconclusive and the need exists to include meaningful uses of technology to produce quality instruction. This study will fill at least part of this existing gap.

Teachers' self-efficacy and ease of use toward technology can influence technology acceptance during instruction. Alenezi (2017) found that self-efficacy was the primary concern teachers had when implementing technology, as well as time, IT support, and lack of resources. However, Teo and Zhou (2017) stated that teachers did not report resources as an issue, but more ease of use and how the technology would be used. Not only ease of use, but also usefulness is a predictor of a teacher's acceptance and attitude toward technology integration in the classroom (Mugo et al., 2017). There are also mixed results regarding teachers' value of technology and content knowledge about self-efficacy beliefs and technology integration.

A teacher's self-efficacy beliefs consistent to technology content knowledge and value toward technology have shown mixed results. Teacher technology content and constructivist pedagogical beliefs show a positive relationship to a teachers' self-efficacy and technology integration (Taimalu & Luik, 2019). Contrarily, traditional pedagogical beliefs and value toward technology show a negative relationship to a teachers' self-efficacy toward technology integration (Taimalu & Luik, 2019). A less recent study by Luik et al. (2017) showed similar results as above; however, value toward technology had shown a positive relationship to a teachers' self-efficacy and technology integration. Preservice teachers also experience similar relationships between technology integration and self-efficacy towards confidence and ease of use with technology.

Scherer et al. (2018) found a positive relationship between pre-service teachers' self-efficacy and technology pedagogical content knowledge, similar to current teachers (Taimalu & Luik, 2019). The higher the preservice teachers' technology pedagogical content knowledge, the higher the teachers' self-efficacy with technology integration was. Technology integration variations and preservice teachers' ability with technology can also have an effect on their self-efficacy toward integrating technology (Lemon & Garvis, 2016).

Self-efficacy experienced by teachers can impact student engagement and achievement. Morris et al. (2016) and Palmer (2006) described the three types of teacher self-efficacy, or stimuli teachers experience: cognitive content mastery, cognitive pedagogical mastery, and simulated modeling. One or all of these three categories of self-efficacy can impact student achievement. (Morris et al., 2016; Palmer, 2006). Teachers experience a higher level of satisfaction when professional performance is effective (Morris et al., 2016). Ikhief and Knight (2016) indicated a need for extensive professional development, to promote teachers' confidence and to increase student-centered learning, to meet the needs of the new inquiry and student engineering practice based NGSS (2017). A need to study factors affecting teachers' self-efficacy exists since contributing factors can impact student performance in the classroom.

Teachers' beliefs and actions have been shown to have a direct impact on student achievement. Thomson and Nietfeld (2016) found significant differences among elementary efficacy beliefs toward science education. Teachers used different actions and teaching strategies for teaching science, dependent on which actions and strategies that the considered most effective. Determining the positive beliefs and actions about which science teaching strategies used by teachers, would give the next necessary steps to improving science achievement among fourth and eighth grade students (Thomson &

Nietfeld, 2016). Savelsbergh et al. (2016) conducted a meta-analysis studying innovative science methods to increase student achievement through attitudes or efficacy. Student attitude and efficacy studies showed a significant effect on effort and engagement, although study designs lacked rigorous achievement measures to gauge student achievement accurately. Zee and Koomen (2016) found that many of the studies looking at teacher self-efficacy focused more on theory and not on student achievement results. Both student and teacher self-efficacy can have a positive or negative influence on student science achievement. Identifying which factors related to teacher self-efficacy are positively influencing science achievement may help other teachers and administrators. Student achievement data and efficacy data could be studied together to understand the influence of efficacy on student achievement better.

Self-efficacy can also impact preservice teachers' level of science knowledge. Knaggs and Sondergeld (2015) examined a possible correlation between science content knowledge and self-efficacy. Preservice teachers, who received the content course, had increased self-efficacy and confidence toward teaching science instruction (Knaggs & Sondergeld, 2015). Similarly, teachers in the classroom received a content course that not only increased self-efficacy with regards to teaching science, but also showed a change in instruction making the instruction more student-centered (Sandholtz & Ringstaff, 2014). Thomson et al. (2016) found that although there was a significant relationship between pedagogical content knowledge and self-efficacy, no significant association was found between domain knowledge and self-efficacy. Domain and content knowledge have been shown to positively influence preteacher self-efficacy, whereas other studies have not demonstrated a direct correlation between pre-content knowledge and higher self-efficacy toward teaching science.

Studies on teacher self-efficacy have indicated similar results across the world. Before 2017, most teacher self-efficacy studies had been completed in the United States (Fackler & Malmberg, 2016). In a current study comparing 14 Organization for Economic Co-operation and Development (OECD) countries, 84% of the variance occurred among teachers and schools, and only 8% among countries (Fackler & Malmberg, 2016). The results from this study help validate the use of international literature and confirm the comparison between international countries and the United States when looking at teacher self-efficacy and science instruction. Principal leadership was a common theme that emerged as having a significant impact on teacher self-efficacy and science teaching in all 14 OECD countries that participated in the study (Fackler & Malmberg, 2016). Mastery goal orientation is another theme arising from teacher self-efficacy that contributes to a positive academic environment (Sakiz, 2015). Teaching self-efficacy is a topic that has emerged among current research and has similar findings globally on the impact of principal leadership and mastery goal orientation can have on science instruction. Noticeably, student engagement is another factor that can contribute to positive and negative science instruction for kindergarten through eighth-grade students.

Student Self-Efficacy, Engagement, and Motivation

Student self-efficacy has been studied to determine relationships between technology acceptance as well as academic achievement. Suana (2018) discovered that females tend to have a higher belief in technology advancing learning than male students and also the older the student, both male and female, the higher the self-efficacy toward technology use. A correlation between students who have a positive experience with technology tend to possess higher self-efficacy toward using technology than students with more negative experiences with technology (Howard et al., 2016). Aside from self-efficacy, interest in the technology has been found to determine the effective implementation of technology during the learning (Ketenci et al., 2019). Race can be a variable when understanding the relationships self-efficacy and academic achievement (Lin-Siegler et al., 2016; Potvin & Hasni, 2014; White et al., 2018).

Self-efficacy has been observed to bridge the gap between race and academic achievement (White et al., 2018). When student self-efficacy is higher, regardless of race, student achievement gaps have narrowed in science (White et al., 2018). Student self-efficacy toward science is a factor affecting student science achievement. Student self-efficacy has been found to have a direct effect on student motivation, engagement, and achievement. Potvin and Hasni (2014) and Lin-Siegler et al. (2016) reviewed the past literature and reported self-efficacy during science to not only has a positive or negative result on science motivation and engagement, but also an impact in the attitude towards science learning. Similarly, Park et al. (2016) found that students as early as first grade believe science achievement and classroom grades could be higher if motivation positively correlated. Gehlbach et al.(2016) found teacher-student relationships influenced student motivation and the students' belief in achievement. Although variance was found in the reasons students become motivated by classroom grades or relationships, student motivation was connected to classroom level science achievement (Gehlbach et al., 2016; Lin-Siegler et al., 2016; Park et al., 2016; Potvin & Hasni, 2014).

Increased Student Engagement during Science Instruction

Shirazi (2017) studied secondary students through personal narrative, by looking for common themes among students' experience of school science and found that students at the secondary level found science to be more difficult than in lower grades, and the instruction was repetitive lacking inquiry and experiential learning. A similar study found that third-grade students also found previous science instruction before beginning an engagement model curriculum to be more challenging and provided hands-on experiment opportunities (Gomez-Arizaga et al., 2016). During student interviews, some students found the writing to be less engaging and distracting from the experiential learning (Gomez-Arizaga et al., 2016). Students appreciated teachers who engaged them in the learning and provided unique opportunities to learn, without the repetitive notions of some science classrooms, which in turn encouraged the students to continue science education.

Several studies (Al-Hammoud et al., 2017; Merchant et al., 2014) have been conducted measuring student engagement during science lessons and have been found to have a direct correlation to student achievement. One specific study by Al-Hammoud et al. (2017) used student response systems to determine impact to student learning. The results indicated that the collaborative response system, which led to a higher engagement, increased student achievement posttest scores. Merchant et al. (2014), meta-analysis compared student achievement with three different technology strategies, computer gaming, virtual learning, and simulations, and found that all three had a positive effect on student learning. Grabau and Ma (2017) analyzed research displaying nine different types of student engagement strategies and found that hands-on engagement strategies had the most effect on student post-achievement data. Hands-on engagement strategies, more particularly inquiry-based instruction will be examined more extensively in the next section.

Student engagement collection measures can vary and be difficult to maintain consistent measures. Sinatra, Heddy, and Lombardi (2015) explained that student engagement can be measured in person or context and can be analyzed using a variety of different grain sizes. This collection can cause a challenge for accurate measurement of student engagement during science instruction (Sinatra et al., 2015). One study found a significant relationship between student engagement in science and students' attitude toward science. However, no significant relationship was found between students' perceived participation in science and science achievement in Malaysia and Japan (Mohtar et al., 2019).

Many countries are conducting comparative research to determine whether available school science resources and motivation toward learning science has a direct effect on science achievement. For example, Lay and Chadrasagaren (2016) completed two comparative studies comparing Malaysia and Singapore and found that students who were in schools where learning resources were not available in Malaysia, had significantly lower science achievement than schools who were not affected by resource shortages (Provasnik & Malley, 2016). Students in Singapore and Malaysia showed similar results regarding motivation toward science, as both countries showed a significant science score increase among students who were motivated to learn science (Lay & Chadrasagaren, 2016). Gender has also been found to have effects on student science instruction and technology.

Gender, Science, and Technology

Gender still continues to play a role in not only science education, but it has some influence on attitudes toward technology integration. Cai et al. (2017) conducted a meta-analysis and found that only a small gap reduction involving teachers' attitudes focused on implementing and using technology. Although the gap was much larger, males were much more confident with technology in the secondary school setting in comparison to the college setting, where the gap was much smaller. Teo and Zhou (2017) and Park et al. (2019) found males scored higher on perceived usefulness than females in regard to accepting technology implementation. However, Teo and Zhou found females scored higher on perceived ease of use than males in regard to accepting technology in the classroom. Preservice teachers and gender have also shown relationships between gender and intent to accept technology in the classroom.

Relationships between preservice teachers' gender and intent to implement technology exist. Baturay et al. (2017) stated that male preservice teachers had a higher computer content knowledge and time spent with technology than female preservice teachers. Therefore, intent to implement technology was predictably higher with male preservice teachers than with female preservice teachers.

Gender is also a factor on acceptance and achievement in science and technology instruction. Males continue to show higher achievement and acceptance in science and technology related subject area, although in some grade levels and science courses females are beginning to close the gap in science achievement. A meta-analysis revealed that males and females were equivalent in most recent life science national assessment results, but males' scores were higher in the earth and physical science (Reilly et al., 2015). Curran and Kellogg (2016) studied the gender differences among kindergarten and first-grade students' science achievement and scores found only a minimal achievement difference between male and female students. Eddy et al. (2014) found that in 21 middle and high-school level biology classrooms, females showed not only an achievement gap, but also a lower participation rate by 20%, in comparison to male students. Mixed groups of female and male students can also have an impact on classroom achievement. Schnittka and Schnittka (2016) found that male groups outperformed female groups, but mixed groups and male groups did significantly better than the female-only groups during middle school science assessment.

Science achievement between specific science content areas and positive attitude toward learning science can also make a difference on gender gap that occurs. Qian et al. (2017) studied national data and found that larger gender gaps existed in the physical and earth sciences, and smaller gender gaps existed in chemistry and biology content areas at the secondary level. Cohen and Chang (2018) found that males had higher levels of academic achievement in science, but also more positive attitudes toward learning science. Gender gaps have been found to occur among students in different science content areas, as well as a correlation between positive attitude and science achievement.

Gender was also a factor on middle school to ninth grade self-efficacy levels. Female middle school and ninth grade students scored had lower science self-efficacy than male students, and also had lower science hardiness levels than those levels of male students (Wang & Tsai, 2016). Self-efficacy is often studied with self-concept, although recent studies find differences among the two. Jansen et al. (2015) found that some studied showed nearly identical results for student self-concept and self-efficacy in relation to science instruction. Although, other studies found differences among student self-concept and self-efficacy, proving that not all antecedents affect student self-concept and self-efficacy the same way (Jansen et al., 2015). Other studies have evidence to support that attitudes toward science and student self-efficacy do not have a significant relationship to science achievement. Mohtar et al. (2019) studied non-cognitive student assessment factors in Malaysia and Japan and found no significant relationship between student's attitudes toward science and achievement in either country.

Specific attitude types toward science also yielded different results. Students' attitudes toward engineering specific science did not correlate with student achievement in science. Salmi et al. (2016) compared engineering attitude and societal attitudes in four different countries and found male students had higher engineering attitudes than female students. Societal attitudes did not have a gender relationship, but a relationship to achievement; the higher the achievement level, the higher students viewed science as necessary in society (Salmi et al., 2016). In addition to gender, race is still showing some recent impact on science instruction.

Race and Science Achievement

Although race still seems to be impacting science achievement, some studies have found the gap to be decreasing or have found no significant relationships exists between race and science achievement. Curran and Kellogg (2016) found that even with control over students' socioeconomic status, a racial gap still existed in primary school science achievement. In a similar study, race was a predictor when determining science achievement at the middle and secondary school level (Cohen & Chang, 2018). The Nation's Report Card (NAEP, 2015) showed a significant racial gap decrease in fourth and eighth grade science scores from 2009 to 2015. Twelfth-grade racial gaps remained unchanged from 2009 to 2015 (NAEP, 2015). Though there is still evidence that racial differences do occur, the gap appears to be narrowing between grades four and eight. Inquiry-based instruction has been shown as a need to allow for effective science instruction.

Inquiry-Based Instruction

Teachers and the results of some studies indicated inquiry as a need in the classroom for effective science instruction. Thomson and Gregory (2013) had one theme emerge during the case study, which was based on science-teaching strategies. Hands-on, or inquiry-based instruction, including making predictions, experimenting, journaling, hypothesizing, and applying knowledge, were the strategies that created the most robust inquiry-based environment. All of these strategies relate to inquiry-based instruction, where students are constructing meaning through hands-on experiences and building inquiry during the learning process (Thomson & Gregory, 2013). Zhang et al. (2015) concluded that statistically, teaching a science unit with inquiry or scientific reasoning was one of the highest areas in which teachers self-identified for improvement. Science teaching strategies and instructional methods are strongly linked to not only teacher self-efficacy, but also student science achievement.

Course design set up to have higher levels of student inquiry, and lower levels of interactivity, have shown a positive impact on motivation. Salgado et al. (2018) observed an increase in student motivation and self-efficacy through science instruction designed to be student-focused; using inquiry and collaborative group strategies, However, Salgado et al. found no significant increase in student academic achievement between the control and intervention group. In a similar study, Inoue et al. (2019) found that a holistic course design, adaptability, and inclusiveness were necessary for successful inquiry-based learning to occur. However, Asada et al. (2019) did not address student achievement, but instead looked at whole person development. Some studies have indicated success in science academic achievement, while others have not noted the same positive outcome; or have not addressed academic achievement.

Some studies have shown no differences between students receiving direct instruction, and those receiving inquiry-based instruction. Lazonder and Egberink (2013) completed a study with a control group having the learning objectives in a set order for the students to work through and another group in control of when the learning objectives were addressed and both groups achieved similar results on the posttest. However, the control group had higher achievement gains from pretest to posttest. Lazonder and Harmsen's (2016) meta-analysis of 74 studies revealed that there is still much controversy to whether inquiry-based learning is yielding high student achievement results, and that most positive outcomes had a high level of student and teacher support and direction during instruction. Although some studies have shown positive outcomes using inquiry-based instruction, it is unclear why some yield positive results and others do not show positive outcomes. In addition to inquiry-based instruction, outreach science instruction and activities has been found to effect student science instruction and attitudes toward science.

Outreach Science Activities

Science outreach activities have had a direct impact on science achievement, but some research studies have shown that community outreach activities do not have a immediate impact on science achievement. Whitesell (2016) conducted a longitudinal study; of students participating in field trips and found slightly higher standardized science assessments; in field trip students compared to those students who did not participate in field trips. An experimental, hands-on, project-based curriculum shared between the school system and community outreach also saw a pre-post significant improvement on K-12 science knowledge in seven of eight content areas (Shuda et al., 2016). Similarly, Camasso and Jagannathan (2017) found that only one-quarter of the cohort groups showed a significant improvement between pre- and post-science assessments after completing an outdoor outreach program in conjunction with the standard science instruction. Itzek-Greulich et al. (2015) found no significant difference between traditional classroom achievement scores and outreach lab student achievement scores. Mohtar et al. (2019) discussed Japan's intense focus on outdoor science outreach learning and noted their high international ranking in science. The study implied that outdoor learning could be a non-cognitive factor in Japan's high science achievement (Mohtar et al., 2019). Although some research has shown a positive result in science achievement, other research has not shown a positive result in outreach activities increasing students' science knowledge or achievement scores.

Outreach activities have also been studied to determine whether or not the learning environment can change a student's attitude toward STEM instruction. Vennix et al. (2018) found that students in the autonomous outreach group had significantly more positive attitudes toward STEM instruction compared to students in a traditional classroom control setting. Levine et al. (2017) addressed female middle school student perceptions during a weeklong outreach camp. Female students attending the camp had more positive attitudes toward STEM curriculum, and more positive attitudes toward their science abilities following the week camp, than female students who had not attended the camp. Problem-based learning is another theme in recent literature that has been found to have a direct effect, both positive and a neutral effect on science instruction.

Problem-Based Learning

Problem-based learning has produced positive and neutral results on classroom level science-technology indicators, student achievement and science instruction. Problem-based learning follows a social constructivist approach to learning science by working in collaborative, controlled settings and students have the opportunity to construct meaning through a reciprocal process (Bruner, 2003). Problem based learning was found to increase science-technology engagement and knowledge in scientific literacy (Afriana et al., 2016). The problem-based instruction gave students an opportunity to use technology to solve science-related problems. Review of recent literature and findings show an increase in classroom level pre/postacademic achievement levels, compared to control groups (Ayaz & Soylemez, 2015; Horak & Galluzzo, 2017). Horak and Galluzzo (2017) reported that both the project-based group and direct instruction group made significant achievement gains, the project-based group showed a more substantial increase in academic achievement. In a similar quantitative study, teachers enrolled in a professional development science program and completed at least 150 hours of project-based learning professional development during the current academic year; students showed significantly higher achievement scores than students' teachers who did not complete the professional development hours (Merritt et al., 2017).

In contrast to problem-based learning producing positive results, Kizkapan and Bektas (2017) found no significant difference between the social constructivist and project-based student group, and the control group in achievement gains. Furthermore, no studies have been completed to examine student achievement on annual standardized testing and the impact problem-based learning has on the standardized achievement proficiency. Pre-service teachers have also been studied to determine if project-based learning has an effect on science knowledge or efficacy and has been successful. Mahasneh and Alwan (2018) explained a positive growth between pre- and post-science knowledge and an increase in self-efficacy among student teachers in a science methods college course. Literacy is also connected to science instruction and technology in recent literature.

Science and Literacy

Recent studies have been done in regard to literacy in connection to technology and science instruction. One study used game-based learning with e-books supplementing the instruction (Wang, 2019). The study found that teachers responded very positively to the e-books and game-based instruction, especially using the books to supplement and fill in science instruction as necessary. In another study, teachers also found benefit in online e-books and the use of technology while reading during science instruction (Zhang et al., 2019). However, studies have been limited to qualitative results and need to be studied further to determine if the literacy through technology is benefiting science achievement. Since many achievement tests are computer based, literacy and ability to comprehend the assessments has also been studied.

Literacy is also a large part of science instruction due to students being required to read and comprehend the assessments. Research has shown that different learning content uses different vocabulary and words in a different context entirely. Winn, Choi and Hand (2016) compared vocabulary used in Common Core State Standard math and the NGSS used vocabulary in a different context requiring students to act upon in opposing ways depending on the standards. Assessments are aligned to the standards and could confuse students. Further study to determine the level of impact to student science comprehension would help to understand better the literary variance students understand.

Scientific literacy makes up science-specific vocabulary and is necessary for students to be able to think critically to be successful in understanding higher level questioning. Vieira and Vieira (2015) stated that ensuing the knowledge of necessary scientific vocabulary and critical thinking instruction, students performed better at the classroom level, than students without the scientific literacy and critical thinking instruction. Avikasari et al. (2018) found that students who received science-themed literacy instruction, achieved higher on a pre and post-test comparison than students who did not receive the literacy instruction. The literacy instruction used in the study had many science vocabulary terms students needed to know to be successful during science instruction and assessments. In a similar study, Masfuah and Fakhriyah (2017) found student showed higher levels of understanding during project-based learning if given a science terms literacy comprehension course, compared to students who did not receive the course. Scientific literacy instruction has proved to be effective by increasing pre-post assessments and higher-level understanding during project-based learning. Dual-language instruction has shown benefits to student science instruction.

Dual-Language Science Instruction

Dual-language instruction is valued by school districts and employed by schools across the United States. Children as young as 2-years, can experience dual-language instructional benefits, such as increased language development, improved social-emotional skills, and also increased age level assessments in toddler and preschool age students, in comparison to students not in dual-language environments (Yazejian et al., 2015). Teachers showed similar interest during a case study a need to employ more dual-language teachers in schools and also prepare pre-service teachers to take a second language in college to help support dual-language science instruction at the middle school level (Lachance, 2018). Dual-language instruction could be studied further to determine the impact the instruction might have on national science proficiency among 4th and 8th grade students, because there are proven instructional and learning benefits associated with the delivery of dual-language.

Nature of Science (NOS)

NOS is a way of thinking about science and the phenomenon that is part of science. Teacher understanding of NOS varies dependent on factors, such as teaching experience, and the teacher's content exposure to the NGSS. Wong et al., 2016) studied teachers completing their master's degree and receiving two semesters of Nature of Science online education and concluded that both science and math educators had a similar level of NOS conceptually understanding. There was no significant difference among beginning and experienced teachers (Wong et al., 2016). Although NOS understanding increased, the increase was not to a high level of achievement and still showed room for improvement (Wong et al., 2016). Yoon and Kim (2016) found no significant difference between preservice teachers' conceptual understanding of NOS and constructivist teaching. McComas and Nouri (2016) found that NOS was deeply embedded in the NGSS; more specifically, 76% of NOS core principles were located in scientific practices. Due to the high level at which the NOS is embedded, conceptual understanding of scientific practices could vary dependent on a teacher's level of NOS knowledge. Aside from strategies to increase effective science instruction, assessment models have also been studied in recent literature.

Classroom Level Assessment Models

Technology and computer-based assessment models have been found to not only increase student engagement, but also increase student achievement. A meta-analysis found that using computer-based assessment models, such as interactive quizzes and assessments, increased both student engagement and also student science achievement (Savelsbergh et al., 2016). Another similar study found that student engagement was significantly higher when assessments were on mobile devices or computer-based (Nikou & Economides, 2016). Both studies (Nikou & Economides, 2016; Savelsbergh et al., 2016) determined the need for further study to understand specifically what implementations had been made and to what extent student achievement increased.

The degree of assessment difficulty to support argumentation, critical thinking and higher order assessments, can create difficulty assessing the instruction accurately. McNeill et al. (2015) looked at student argumentation in science assessment by determining which contexts, such as vignettes, student writing and video as ways to assess if argumentation is taking place during science instruction. Teachers need to be able to have evaluation abilities, through pedagogical content knowledge beyond surface level pseudo argumentation (McNeil et al., 2015). Studies show that there is a strong correlation between student math and science achievement **(**Bicer et al., 2017; Cetin et al., 2015). Most recent studies have developed a higher order assessment model when math and science standards are assessed together in a STEM model (Bicer et al., 2017).

Elementary and middle school have a lack of assessments in the area of scientific engineering and STEM model practices, making it difficult to assess the effectiveness of STEM instruction (Bicer et al., 2017).

In other studies related to classroom level science assessment, Sahin and Ozturk (2018) found that student self-confidence and regional or national assessments were the only predictors on student achievement on standardized assessments. Classroom-level assessments showed no relationship as a predictor to student achievement on standardized assessments. Sahin and Ozturk discussed the lower cognitive skills required for classroom level assessments in comparison to the higher cognitive skills needed on standardized assessments, such as state and national Programme for International Assessment (PISA) assessments. Assessment is an integral part of science instruction, and understanding the history of assessments and achievement is important to see the whole picture in regard to science instruction and achievement.

History of Science Achievement

Over the past decade, the United States has demonstrated low levels of science achievement from elementary school to the high school level. (PISA, 2009, 2015). The National Science Foundation (NSF, 2015) acknowledged the need to improve K-12 science achievement in the United States. Yoon et al. (2017) defined the need for a consistent, inclusive science education framework that creates a complex system of learning. Many states have not adopted in entirety the national level NGSS (2017) to create a consistent and inclusive science education framework, creating a complex system of crosscutting concepts. These findings help support the research, by showing inconsistencies among schools in the United States. Because all schools have not adopted the same framework for which standards are taught, it is highly valuable to determine which efforts are creating a positive impact on student science instruction.

The United States has mandated public schools in the U.S. to participate in a NAEP Nation's Report Card assessment. In 1969, NAEP began under a mandate of the National Center of Educational Statistics, which is part of the U.S. Department of Education and the Institute of Educational Sciences (IES: About NAEP, 2015). The NAEP (2015) was created to help study educational achievement in the United States and compare student science achievement on a global scale. Future science achievement can be tracked between different states and the entire United States. Access to the NAEP achievement results is helpful to identify states that are achieving at higher and lower levels of science achievement. The evidence is consistent among all students who have taken the Nation's Report Card assessment, which makes the assessment a valid source of data to study when looking the problem researched, low science achievement in the United States. The United States not only ~~is~~ exhibits low science achievement nationally but also shows low science achievement when compared globally.

History of Science Achievement on a Global Scale

On a global scale, the United States is not showing high achievement or growth in science. In comparison to the United States, many countries are demonstrating higher levels of science achievement. The PISA (2015) reported that the United States ranked 25 out of 71 countries participating in the international science assessment (OECD, 2016). In 2009, the PISA reported that the United States ranked 17th out of 65 countries participating (OECD, 2009). Although the United States ranked average among all countries participating, only 29% of students were proficient (OECD, 2016). Both in 2009 and 2015, Finland, China, Japan, and Korea ranked in the top four countries (OECD, 2009, 2015). The United States continues to show a decline in science proficiency in the United States compared to other countries (Jules & Sundberg, 2018; Woessmann, 2016).

History of Science Education in the United States

For accountability purposes, the United States mandates public schools to conduct annual achievement testing in math, reading, and science. United States achievement testing in science began in the 2005-2006 school year, with the passing of the No Child Left Behind (NCLB) Act in 2002 (Human Resources [H.R.], 2011). NCLB stated that the same information, regardless of location, would be tested, later becoming the Common Core State Standards in 2009. Since the 2005-2006 school years, science has been tested in the fourth, eighth, and 12th grades each academic year by each state individually (NCLB, 2011). In 2009 and 2015, all 50 states completed the Nation's Report Card assessment for science (NAEP, 2009, 2015.) All three of the mandated achievement efforts; NCLB, Common Core State Standards, and the Nation's Report Card have been implemented to provide a consistent framework for all states and reporting of academic achievement at the national level.

In 2009, 34% of fourth graders were proficient or advanced, and 66% basic or below a basic level of proficiency (NAEP, 2009). In 2015, 38% of fourth graders were proficient or advanced, and 62% basic or below a basic level of proficiency (NAEP, 2015). In 2009, 30% of eighth graders were proficient or advanced, and 70% basic or below a basic level of proficiency (NAEP, 2009). In 2015, 34% of eighth graders were proficient or advanced, and 66% of eighth graders were basic or below a basic level of proficiency. From 2009 to 2015, both fourth and eighth graders in the United States saw an average of 4% increase in students who were proficient in science.

History of Science Education in the Selected State

Although science proficiency remains low in the selected state, science proficiency has increased among 4th and 8th grade students in recent years. According to the WYDOE (2016), in the past three years there has been an academic achievement increase in fourth and eighth grade state achievement scores. WYDOE (2015) reported a decline in proficiency statewide for the 2014-2015 school year. For the 2016-2017 school year, the WYDOE (2017) reported that the selected state has seen an increase in science proficiency. From 2015-2017, fourth grade students had an almost 4% statewide increase in proficiency from 51.3% to nearly 55% of students proficient or advanced on the Proficiency Assessments for Wyoming Students annual statewide assessment (NAEP, 2015). In addition, eighth-grade students had a roughly 4% statewide increase in proficiency from 41.6% to 45.3% of students proficient or advanced on the same assessment. Wyoming's fourth grade students' average points on the assessment grew from 156 points in 2009 to 161 points in 2015 (NAEP, 2015). Wyoming's fourth grade students scored higher than 35 states, lower than two states, and no significant difference among nine states (NAEP, 2015). Wyoming's eighth grade students' average points on the assessment grew from 158 points in 2009 to 160 points in 2015. Wyoming's eighth grade students scored higher than 29 states, lower than four states, and no significant difference among 14 states (NAEP, 2015). Even with the increase on statewide assessments and the national level assessments given to states, science proficiency is still limited in Wyoming. Wyoming, as well as 36 other states, adopted the ISTE standards to help increase academic achievement through technology integration (ISTE, 2016).

Conclusion

The literature in this chapter was reviewed to gain a full understanding of the problem in the study; teachers do not consistently implement ISTE standards in their pedagogical practices of teaching science. By understanding the existing research themes regarding science instruction trending and how technology is a recent part of science pedagogical research, a broader understanding and gap in literature can be filled by how teachers implement the ISTE standards in their pedagogical practices of teaching science. The theoretical framework, TAM (Davis, 1985), was established by reviewing literature in regard to technology in science education and how it has been accepted and used. Furthermore, by studying literature surrounding teaching and student self-efficacy, a better look at teachers' perceptions and student motivation can be understood and valued in relationship to student achievement and technology implementation and practices. Other factors that have been shown to have both positive and negative influence on science instruction were reviewed. The factors included professional development, teacher certification, student engagement, outreach programs, dual-language science instruction, gender, and Nature of Science phenomenon.

It is well known that particular factors have a positive and negative result on student science motivation and achievement, as well as teacher self-efficacy. It is still unknown from a thorough review of recent literature, what influence each of these factors has in relationship to effective technology implementation and teachers' acceptance of said factors. Understanding teachers' acceptance of the ISTE standards in relationship to teachers' pedagogical understanding and needs is necessary. The present study would fill a gap in the literature by understanding teachers' needs and their perceptions regarding how technology is influencing their pedagogical practices in science and how the teachers' use of a few three selected ISTE standards might innovate their science instruction. In the next chapter, an explanation of research method for the study will be discussed.

Chapter 3: Research Method

Introduction

The purpose of this qualitative study was to understand elementary school teacher perceptions about how they us the three selected ISTE standards to maximize student learning during their pedagogical practices when teaching science. I specifically explored the influence that the recently implemented ISTE standards have had on successful teachers' pedagogical practices. The three ISTE standards chosen for this study were those that directly relate to teachers' pedagogical design, such as resources chosen, adaptive learning experiences, and learning activities (see Crompton, 2017). The three ISTE standards (ISTE, 2016) focused on in this study are:

1. ISTE Student Standard 3: Knowledge Constructor - Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts, and make meaningful learning experiences for themselves and others.
2. ISTE Teacher Standard 5a: Use technology to create, adapt, and personalize learning experiences that foster independent learning and accommodate learners' differences and needs.
3. ISTE Teacher Standard 5b: Design authentic learning activities that align with content area standards and use digital tools and resources to maximize active deep learning.

This chapter includes a discussion of the research design and rationale, central concepts, research tradition and rationale for the chosen tradition, the role of the researcher and observer, participant selection criteria, and instrumentation. This chapter also contains an explanation of the data analysis process, trustworthiness, and ethical procedures.

Research Design and Rationale

Research Questions

At two school districts in the Mountain Region of the United States, elementary schools have seen a rise in science achievement according to state-level standardized achievement testing over the past three years (WYDOE, 2019). To effectively address the research questions, I chose schools for the study that have shown growth in students' science achievement since the recent statewide adoption of the ISTE standards. The following central research question and subquestions guided this study:

Central Research Question: What are the perceptions of elementary school teachers pertaining to the implementation of the selected ISTE standards to maximize student learning in science?

Subquestion A: In what ways do elementary school teachers perceive the three selected ISTE standards to innovate the teaching of science?

Subquestion B: What are elementary school teachers' perceptions of the needs of elementary teachers when technology is used in science instruction to maximize student learning?

Research Tradition

I used a qualitative approach in this study. Since elementary school teacher perceptions are the basis for the study, quantitative and mixed-methods study designs were no selected; rationale for this decision will be explained later in the chapter. A deeper understanding of how elementary school teachers are implementing the ISTE standards in science requires developing an understanding of teacher perceptions, which was more inclined towards the qualitative method. Merriam and Tisdell (2016) defined qualitative research as constructing meaning by engaging in the world in three ways: (a) how people interpret their life experiences, (b) how people construct their worlds, and (c) what meaning people attribute to their said experiences. Qualitative studies are also descriptive, which means meant to describe life experiences (Merriam & Tisdell, 2016). In this study, teachers were allowed to represent their teaching experiences and practices in science instruction, which helped develop a better understanding of teacher perceptions for increased science achievement and the influence technology is having on science instructional practices. Basic qualitative research helps understand meaning surrounding an event or situation, especially when other research traditions are not appropriate for the study design (Maxwell, 2005).

Since I primarily looked to describe perceptions and practices in the study, I used a basic qualitative descriptive design. Caelli et al. (2003) summarized qualitative designs as having a different analytic lens in which to view each study and data being collected. When different specific approaches do not fit a particular analytic lens, the basic qualitative design is a good design to use because it can encompass a combination of varying data collection strategies. Therefore, I selected a generic qualitative design for this study.

Other qualitative approaches, including case study, phenomenology, ethnography, narrative inquiry, and grounded theory, were considered for this study. Phenomenology is defined as the lived experiences of many individuals regarding a phenomenon (Creswell & Creswell, 2018). The purpose of the study was descriptive in nature, so I did not choose a phenomenological design because there was not a specific phenomenon or perception being studied.

Ethnography, which looks to understand a specific culture (Merriam & Tisdell, 2016), was not chosen because a specific group or culture of students was not represented in the study. I did not look at the culture of a particular group in the study but focused on perceptions, and as such, ethnography was not suitable.

Narrative inquiry was another consideration for the design of this study. Narrative inquiry uses the stories of others to help better understand life experiences in the world (Merriam & Tisdell, 2016). Patton (2015) explained that a researcher uses narrative inquiry to develop a deeper understanding of a shared phenomenology or perception. In this study, the focus was to understand teacher perceptions of how they use the selected ISTE standards to maximize student learning during their pedagogical practices when teaching science; therefore, a narrative approach was not appropriate for this study.

The grounded theory design was also considered for this study. Patton (2015) described grounded theory as deductive and helpful to discover a theory or analyze a process beyond the descriptive. The grounded theory design concentrates on building a theory from the gathered data, and since I did not aim to create a theory, the design was rejected as not suitable for this study.

Role of Researcher

I functioned as the primary instrument of data collection and analysis in this qualitative study (see Merriam & Tisdell, 2016). I was responsible for the collection, analysis, and interpretation of data during the study. I was also responsible for the selection of participants, the research design, and the data collection instruments. The data collection instruments included the interview protocol, Zoom video conferencing, and a data collection notebook. I identified a source for each data collection instrument and made sure that each instrument accurately collected the data. In addition, I handled all participant recruitment procedures.

Minimizing the potential for researcher bias and establishing the trustworthiness of the qualitative research was my responsibility as the researcher. I used strategies to increase trustworthiness by triangulating the data, recruiting participants in an area I have not taught in, and adopting reflexivity in the research process, which I will address in more detail later in this chapter.

I am currently a lecturer in a state university, and I took the necessary precautions to prevent any personal connections and biases from affecting the study. Before taking the lecturer position this school year, I was an elementary educator in the state where the research took place. I purposefully selected school districts outside the area I taught in for the last 7 years. This eliminated personal connections and bias I may have had with any possible participants because I did not have any familiarity or relationships with the teachers in the districts used in the study.

Participant Selection Logic

Typical, unique, maximum variation, convenience, and snowball or chain-reaction are the specific types of purposeful sampling that can be adapted to select the participants (Creswell & Creswell, 2018). A typical sample can identify what is regular or average in a given population (Creswell & Creswell, 2018). I chose typical sampling as the type of purposeful sampling for this study because it best provided the sample I looked to represent (i.e., elementary science teachers who have had positive results in science achievement).

Brinkmann (2013) stated that in a qualitative interview process, no more than 15 interviews should be conducted in a single study. Conducting too many interviews can make it challenging to get to know the participants in a more personalized setting. During the typical sampling process and the current pandemic situation, I had difficulty scheduling interviews. In addition to typical sampling, snowball sampling also aided in the participation selection process. One of the interview participants contacted another potential participant, and this process continued until I reached the necessary number of participants.

Participant Population

The participants for this study included 11 fourth grade science teachers recruited from two districts. The identified school districts were located in the Mountain Region of the United States. I selected participants using the following specific criteria to meet the requirements of the study: (a) must have taught science in the fourth grade a minimum of 1 school year, (b) must have been part of the same school district the previous year, and (c) must have been assigned to one of the schools in which an increase in science achievement has occurred.

I obtained verification that the participants met the inclusion criteria from the school district superintendent, building level principal, and teachers. None of the participants were drawn from schools where science proficiency had not increased during the last 3 years. It was essential to only select teachers who met the above criteria to have valid results that met the purpose of the study to identify teacher perceptions and practices of teaching methods that positively influence science proficiency. Merriam and Tisdell (2016) explained that when a specific criterion is established or purposeful selection is adopted, the participants could address the purpose better and more effectively.

Once the teachers who met the inclusion criteria were verified, I gained permission from the superintendent and building principals to recruit participants for the study. Teachers were contacted in with an email that explained the purpose of the study and asked the teachers to participate in the study. To account for attrition, I contacted at least 34 teachers in writing. If teachers were interested in participating in being interviewed, I asked them to email or telephone their interest to me within 7 days of receiving my initial email. At the end of the 7 days, I contacted each of the interested teachers to confirm interest and schedule their interview. I then sent the list of teachers who had confirmed their interest to participate in the study to the district contact to make sure the principals approved their participation. If more than 10 teachers would have showed interest, I would have selected participants based on the date of email or phone call received from them, selecting the earliest email or phone call dates first.

The relationship between sample size and saturation starts with analyzing patterns and commonalities in the data from the interviews (Ravitch & Carl, 2016). Ravitch and Carl (2016) stated that if no new information was coded and the data from the interviews developed redundancy, that no new interviews would be added beyond the original 10 interviews scheduled. In the event that most interviews were different or continued to be coded and contained new information, I would have made a decision on whether to conduct more interviews was made based on saturation.

Instrumentation

For this study, I conducted individual interviews with participants to collect qualitative data. Specific questions that aligned with the research questions were asked during individual interview sessions. The interview protocol in Appendix A guided the interview sessions. A research journal and lesson plans were also used during the individual interviews and data analysis.

Individual Interviews

Interviewing has been defined as a process of engagement between the participant and the researcher intended to focus on questions that are related to the research question(s) for the study (DeMarrais & Lapan, 2017). Bogdan and Biklen (2016) described interviewing as an opportunity to establish rapport and a personal connection with the participants. Interviews can assist in understanding participants on their terms and use a cognitive process to bring out life experiences and help make meaning around a particular experience (Green et al., 2012). Merriam and Tisdell (2016) discussed that there are three most popular types of interviews: standard or highly structured interviews, semistructured interviews, and unstructured interviews. Standard or highly structured interviews often work well with survey type questions, and answers most often have a predetermined answer to them. Semistructured interviews have a mixture of structured and unstructured questions, some questions have open-ended answer possibilities, and the wording and answers are not predetermined. Unstructured or open-ended interviews are the most common and used in designs where the conversational approach is most appropriate.

The person-to-person setting is the most common for all three interview types, although group settings and internet-based settings can also be used (Merriam & Tisdell, 2016). After reviewing all three types of interviews, it was decided that a semi-structured, person-to-person approach was be used for the individual interviews during this study. The interview questions were a combination of less structured questions, some of which were open-ended questions.

The interview protocol included the interview questions and also what research question aligned with each interview question. Maxwell (2005) states that the questions serve two purposes, (a) to keep the study focused and (b) to provide guidance on how to conduct the research. Table 1 shows the interview questions that guided each research question. The interview questions were reviewed and accepted by the dissertation committee members after validating that the questions aligned with the research questions and would elicit appropriate responses to answer the research questions.

The interview protocol was checked for validity by doing a trial run of the questions prior to the interviews taking place. I asked the interview questions to two elementary science teachers. By doing this, I ensured that the questions being asked were eliciting the necessary responses to answer the research questions. A trial run of the interview protocol also increased the validity and established sufficiency with the researcher-developed instrument.

Table 1

Interview Questions

	Interview Questions:
Rapport Building Questions:	i. Tell me about your journey that has brought you to the current setting you are teaching at? ii. Do you enjoy teaching? iii. How long have you been teaching? iv. How long have you taught at your current elementary school? v. v. What are your favorite subjects? Is science one of them?
Overall Research Question: What are the perceptions of elementary school teachers pertaining to the implementation of ISTE standards to maximize student learning in science?	1. Do you perceive ISTE standards as essential when teaching science? 2. Do you use any specific pedagogical strategies to achieve the above objective? 3. Do you perceive ISTE standards as essential when teaching science? 4. Do you use any specific pedagogical strategies to achieve the above objective?
Sub Research Question i: In what ways do the three selected ISTE standards innovate the teaching of science?	5. What innovative strategies do you adopt? 6. Do you feel that the three selected ISTE standards influence your pedagogical practices of teaching science? 7. What specific types of ISTE related technology do you find the most innovative? 8. How does the implementation of the ISTE related technology affect your pedagogical practices? 9. Do you use any specific pedagogical strategies to achieve the above objective? 10. What innovative strategies do you

	Interview Questions:
	adopt? 11. Do you feel that the three selected ISTE standards influence your pedagogical practices of teaching science? 12. What specific types of ISTE related technology do you find the most innovative? 13. How does the implementation of the ISTE related technology affect your pedagogical practices?
Sub Research Question ii: In what ways do the three selected ISTE standards innovate the teaching of science?	14. What specific types of ISTE related technology do you find most useful? 15. What specific types of technology do you find the least innovative? 16. What specific types of technology do you find the least useful? 17. Do you feel that you require more guidance to implement the selected ISTE standards to maximize student learning? Have you any other needs like physical resources, overall supervision, more time. etc.?

Recruitment, Participation and Data Collection Procedures

During recruitment, participation, and data collection, explicit procedures were utilized, which will be discussed in more detail further in this section. Following specific evidence-based procedures also increased the trustworthiness of the research and overall study. Individual interview recruitment, participation, and data collection procedures are discussed below.

Recruitment

The first step I took in the recruitment process was to contact the district-level point of contact for any research done in the school district. As part of the district requirements for preapproval, it is to send a written request asking for permission to utilize research participants in the school district. Once preapproval from the school district was completed, I then initiated collaborative efforts with the curriculum and instruction superintendent, who selected the teachers that met the criteria for the research. According to rules prevalent in the state chosen for the study, which is situated in the Mountain Region of the United States, school districts may disclose general information, such as address and phone number, if the custodian of the records deems it appropriate for official business. In this case, the district superintendent, or in some cases, the principal at the school, would be the custodian of teacher records. Once I received a list of teachers who met the criteria, I reached out in writing, by email, and made a personal phone call, if necessary, inviting each of them to be a part of the individual interviews. According to Merriam (1998), volunteer rates average 15%-30%. I sent out more invitations than the ten participants I will require for the study since there was a likelihood that not all teachers would agree to be interviewed. I accounted for attrition by interviewing more participants than needed for the study. I started by sending out 34 invitations. Walden's permission process requires invitations be sent to possible participants and informed consent letters had to be signed by participants prior to participation in the interviews.

Participation

To acquire the necessary participation, I sent out invitations to participate in the study based on teachers meeting the criteria according to the district principals. Once I reached the necessary participant numbers and received the consent to participate forms by email, I called each participant to thank them for their willingness to participate in the interviews. During the phone call, I scheduled individual interview times and checked for any questions or concerns the participants might have pertaining to the study. I asked them to email a few copies of their recent science lesson plans to refer to and used the lessons during data analysis to determine the technological adoption. The lesson plan evaluation tool in Appendix B was created to analyze the lesson plans.

To have the necessary privacy needed during the interview sessions, I secured and scheduled a Zoom online session and emailed the link to each participant. Each interview was given a 45-minute time slot. All interviews asked the same interview questions as listed in the interview protocol, which aligned with the research questions for the study. Atkins and Wallace (2012) recommended an informal and comfortable interview setting where both the interviewer and interviewee sit in chairs at right angles to one another, not face-to-face, and I intended to adopt the same system. In this case, since interviews were conducted via Zoom, I was not able to adopt the face-to-face system.

Data Collection

Individual interviews were video recorded on video recording software. Atkins and Wallace (2012) explained the benefits of video recording to be the ability to capture the entire transcription of the interview, and also provide the interviewer an opportunity to analyze their skills and areas to improve. As a backup, an audio recording of each interview was done, if something happened in error to the video recording.

The night before the interviews, all necessary materials were gathered. Necessary materials included a laptop for the video and audio recording, charging cords, a researcher diary for reflexivity, and copies of the interview questions for myself as well as the participants. On the day of the interview, I started the Zoom link for the interview 15 minutes early with all the necessary interview materials. During the greeting and initial meeting process, I introduced myself again, and thanked each participant again for his or her willingness to participate in the study. Before starting the interview questions, I explained the procedures for the interview process and follow-up with results of the study at a later date in writing. During the interview, specific questioning strategies were used, beginning with the rapport building questions and followed by questions designed to answer the research questions.

During the interview, I, as the primary research instrument, had a responsibility to pay attention to verbal and non-verbal cues that are given by the participant. Hatch (2002) explained that probes or follow-up questions are not pre-planned, but are questions asked during the interview to elicit more information. Pauses and emphasis made by the participant can be an opportunity to have the participant explain in more detail about a given answer. Nonverbal cues, such as body language, can also be used as an opportunity for follow-up questions (Hatch, 2002).

Starting with the rapport building questions, I got to know the participants by learning some necessary demographic information and background knowledge about each participant and helped the participant to relax. Hatch (2002) described these questions as throwaway questions, intended to make the participant comfortable. Throwaway questions can also be used throughout the interview if the interview starts to become stressful and a break is needed. Once the participant was comfortable and the rapport building questions had been asked, I began asking interview questions in order. After the interview, participants were asked a closing question to follow-up and ensure the participants did not have any questions or information they would like to add. I then thanked them for participating in the interview process and stated that the interview was complete prior to dismissing the participant.

Data Analysis

After conducting all of the interviews, I began the data analysis by transcribing the interviews myself, along with the notes from the lesson plan scrutiny. The process I used was to have the interview audio transcribed through a program first. If necessary, in the event that the video is unavailable or damaged, I used the back-up audio recording and could have the recording transcribed in the same manner. I then took the transcriptions and went through them one by one listening to the audio interview to make sure they read correctly. Prior to starting the coding process, I read and became familiar with the transcriptions. The next step in the data analysis was to go through two levels of coding with the interview transcriptions. In the first level, each interview was coded. Patton (2015) described coding as a process to interpret, classify, and describe the data and allow the researcher to sort the data into categories. Within those steps, the researcher is making meaning through implicit and explicit dimensions in the data. The explicit meaning will be information directly stated, whereas implicit meanings will be implied through something that was reported during the interview.

Step one in the coding process can be done multiple times, each time with a distinct purpose (Ravitch & Carl, 2016). For example, the first read was looking for information that stood out. The second and subsequent reads were looking for specific information related to each research question. The second step in the coding process was to take the explicit data from the step one coding process and begin to analyze and cross-compare (Merriam & Tisdell, 2016). For instance, the first time through was looking for commonalities in the interview data. I was also looking for a connection of data to each research question and determined if the data was aligning to the research questions.

When coding each individual interview, Merriam and Tisdell (2016) suggested coding each interview as you go along and not wait until all interviews are completed. Waiting until all interviews are completed to begin coding was not suggested for two reasons, you begin to forget the details of each interview, and each interview should inform the next. Patton (2015) described saturation, as reaching the point in the interviews when no new information is being gained in the interviews. Each initial coding process built upon one another. For instance, if by interview number 8 the interviews were very repetitive, and new information was not revealed, the saturation point would have been met. Once the last interview was coded, the first level of coding would be complete. If additional or follow-up interviews were not necessary, the second level of coding continued the coding process.

The second time coding the data analyzed differences in the interview data. Common themes began to emerge from the data. Once common themes began to emerge, the themes were examined to see how the themes related to each research question. Significant findings were then discussed. This can also be referred to as deductive coding (Patton, 2015). Deductive coding examines the implications that can be derived from the data.

NVivo (n.d.) software was used after the first two times coding the data. NVivo searched for themes in the interview data. Zamawe (2015) found evidence-based implications that computer-assisted data analysis software was effective at aiding in the data analysis process and was not intended to replace the researcher's role as the primary data analysis instrument. This allowed me as the researcher the opportunity to validate the current themes that have been found in the data, as well as identify additional themes in the data that might have been overlooked or not recognized.

The research journal notes from the lesson plans were crosschecked with the date gathered at the interviews to help triangulate the data and verify the themes that emerged. Themes such as online science programs appeared in both interview questions as well as the online science program lessons. Divergence, such as a theme only emerging during the interviews, were listed as discrepant findings. These findings were unrelated to the research questions, however, provided valuable insights to the conclusions of the study.

Issues of Trustworthiness

Having evidence of trustworthiness during the research process was essential. Atkins and Wallace (2012) defined trustworthiness as being honest, genuine, and based on sound research ethics. They also discuss how important it is to consider the trustworthiness of the research evidence. Patton (2015) described constructivist trustworthiness as trustworthy, which is credibility, transferability, dependability, and confirmability. These steps are described in more detail in the sections below.

Credibility

Credibility is valuable to create belief in not only the researcher but also the data during the study. Patton (2015) stated how triangulation in data collection and analysis can increase credibility. Having more than one source of data, by having various data points or sources, allows the opportunity for evidence to be present more than a single occurrence. Merriam and Tisdell (2016) discussed the connection between internal validity and credibility. By having an internal validity source, which in this case, is the researcher, you are also adding credibility to the research. Strategies to increase credibility can include multiple research methods, multiple data collection modalities, multiple sources of data, and multiple theories to allow data to emerge in a variety of ways.

The Department of Health, Education & Welfare (1978) issued the Belmont Report and discussed appropriate ways to ensure participants are selected with confidence and proper procedures. To ensure credibility and higher confidence among the participants, the researcher must make sure participants have been given all information on the study during the consent and that the participants have a full understanding of what the research is pertaining to.

Transferability

When setting up the research questions, I made sure that the findings of the study were transferable, meaning whether the entire research process could be used in future research. Merriam and Tisdell (2016) explained to create transferability, a full description of the findings, participants, and setting are necessary. This allows future researchers to assess similarities and find future research potential and literature for new research to take place.

Dependability

Dependability can be defined as a parallel to reliability (Patton, 2015). Patton (2015) described dependability as needing to be logical, traceable, and documented. Having documented steps explaining the study, such as the interview guide and questions, will ensure that the study is not only documented but also logical in process. The audio recordings, as well as the transcripts from the interviews, created a traceable process. If an interview or data set was questioned, the data was readily verifiable and documented.

Confirmability

Confirmability in qualitative research is defined by the qualitative results being able to be confirmed in numerous ways (Merriam & Tisdell, 2016). By looking for reoccurring ideas, themes, images, and answers in the data, confirmability will take place (Atkins & Wallace, 2012). I used a research journal to record my experiences and events during the data collection process. By using a research journal, I reflected on any bias or assumptions and ensured they did not interfere with my findings.

Member checks were done to increase confirmability. Ravitch and Carl (2016) explained member checks as a check in to validate that what was transcribed and coded is accurate and as close as possible to what the participant said during the interview. Conducting member checks alone does not confirm accuracy, although done in combination with the research journal, and performing the member checks increased the confirmability of the study (Ravitch & Carl, 2016).

Ethical Procedures – Treatment of Participants

Obtain Legal Consent

Consent from the participants, but also the school district where the interviews took place, was obtained. The permission was obtained in writing from both the district and the interview participants. As part of the legal consent, information regarding confidentiality, anonymity, benefits and risks, and cause no harm intent was provided in writing along with the written request for consent. The Department of Health, Education, & Welfare (1978) explained in the Belmont Report an informed consent process consists of information, comprehension, and voluntariness. Participants were given sufficient information regarding the study, understood the information given, and were willing to volunteer to participate in the study.

Confidentiality and Anonymity

During the written request to obtain legal consent from the district and the participants, explanations of confidentiality and anonymity were given in writing. Patton (2015) explained that participants' names, locations, and any other identifying information should be concealed to protect the participant's personal information.

Participants and the school district were informed that all personal information, including real district names and participants' names, were not to be used. Instead of real names, pseudo names were given to the district and schools involved, as well as all participants being interviewed. Participants and schools were given the pseudo name to locate the school and participants in the findings of the study. Personal information of participants was safeguarded to protect participants' legal information and privacy. Data will only be available to participants, the researcher, and the dissertation committee. Data will be destroyed 5 years after the study is conducted.

Since no students are being used in the study, risks are very low to non-existent. The benefits will far outweigh any minimal risk that could be associated with the study. Any risks relevant to the study would be outlined in the legal consent process (Department of Health, Education, & Welfare, 1978). Committees for human subject protection, such as the Institutional Review Board (IRB), were in place to make sure participants were not at undue risk during the study (Patton, 2015).

Causing harm to participants needed to be considered prior to conducting the study. The Belmont Report refers to physical and psychological harm being the most common, although legal harm, social harm, and economic harm should also be considered when reviewing any risks associated with the study (Department of Health, Education, & Welfare, 1978). They also explain that procedures for handling issues should be in place before any interviews taking place. I ensured that participants were briefed that no harm will come to them, and at any time during the interview or study process, they were allowed to withdraw from the study immediately. The IRB also served as checks and balances as to the treatment of participants. Prior to conducting the study, the IRB reviewed the entire study for proper ethical procedures. The IRB approval number is 04-23-20-0658727.

Summary

In this chapter, I discussed research design and rationale, role of the researcher, methodology, evidence of trustworthiness, and ethical procedures. The research design chosen, was a basic qualitative study design since I was trying to understand and be informed about a perspective or process (Merriam & Tisdell, 2016). I served as the primary researcher during the study. I was responsible for the selection of the research design, participants, data collection, analysis, and interpretation. I was also responsible for the data collection instruments used. The methodology consisted of eleven interviews of elementary science content teachers. The teachers were selected based on meeting specific criteria to collect accurate interview data and upon signing a letter of consent to participate. Instrumentation to collect data included the interview questions, transcripts of each completed interview, data collection form or notebook, and a recording device to record the interviews to analyze the data.

Once the interviews were completed, data analysis was conducted. Each interview was recorded and then transcribed. A two-level coding process took place. The first level of coding, I coded each interview separately, looking for implicit and explicit data to emerge until saturation had been met, or all interviews were exhausted (Patton, 2015). In the second level of coding, I conducted a cross-comparison or analysis for themes to emerge from the initial coding findings. The final step in the data analysis process was processing the interview data through the NVivo (n.d) program to validate themes that I, as the researcher, found and also looked for new themes in the data and themes that were not directly related to the research questions.

Evidence of trustworthiness, which included credibility, transferability, and confirmability, was considered during the data collection and analysis of the data. Providing evidence of trustworthiness is essential to produce a study that does not lack trust in any way. In addition to trustworthiness, ethical procedures were also taken into high regard during the study. Legal consent, confidentiality, anonymity, benefits outweighing risks, and cause no harm, are components of ethical procedures were contemplated. The next chapter will discuss the results of the study.

Chapter 4: Results

Introduction

The purpose of this qualitative study was to understand elementary school teachers' perceptions about how they are using the three selected ISTE standards to maximize student learning during their pedagogical practices when teaching elementary science. Understanding teacher's perceptions of what they identify as necessary to maximize student achievement in science could help increase science achievement in the selected school districts and possibly improve science instruction at the community and the state level. In this chapter, I begin by describing the setting of the study. The description of the setting is followed by a discussion of the demographics, data collection, data analysis, evidence of trustworthiness, results, the implications for social change, and a conclusion.

The following research questions guided this study:

Central Research Question: What are the perceptions of elementary school teachers pertaining to the implementation of the selected ISTE standards to maximize student learning in science?

Subquestion A: In what ways do elementary school teachers perceive the three selected ISTE standards innovating the teaching of science?

Subquestion B: What are elementary school teachers' perceptions of the needs of elementary teachers when technology is used in science instruction to maximize student learning?

I conducted semistructured interviews via Zoom with 11 fourth grade science teachers from two school districts. In addition to the interviews, I reviewed the science lesson plans provided by nine of the teachers who were interviewed. The lesson plans were used as an additional data collection source and helped to clarify how the selected ISTE standards were being implemented into science instruction. Both the interviews that were conducted and the content analysis of the science lesson plans provided the data needed to answer the research questions effectively (see Yin, 2016).

Setting

The setting of the study was in two school districts located in a state in the Mountain Region of the United States. The study was restricted to these school districts that had seen an increase in science achievement and were currently exceeding the state average in science proficiency for fourth grade students at the time of the study. There was approximately 50 total school districts in this particular state in the Mountain Region of the United States; however, only six districts met the inclusion criteria for the study. The participant inclusion criteria were: (a) must have taught science in the fourth grade a minimum of 1 school year, (b) must have been part of the same school district the previous year, and (c) must have been assigned to one of the schools in which an increase in science achievement had occurred.

To maintain quality of the data and recruit participants that met the required criteria, purposive sampling was necessary (see Tongco, 2007). Out of the six school districts that met the criteria, two agreed to participate in the study. The criteria for the school districts were that the district was excelling in science by being above the state average for fourth grade assessment scores and had seen an increase in science achievement. Fourth grade teachers were invited to participate in the study, and 11 teachers voluntarily chose to participate. Due to the pandemic taking place, it was extremely difficult to contact many of the schools that had moved to online instruction only.

Demographics

All of the fourth grade teachers who were selected to participate in the study were interviewed and shared lesson plans with me. All 11 participants had been teaching fourth grade science during the past 2 years. Table 2 shows the list of the participants, the district they were from, how long they had been teaching, and the number of years they had been teaching fourth grade. Each of the 11 teachers who participated in the study contributed to fourth grade science instruction, either as the science teacher who integrated science through literacy instruction or as the K-5 STEM teacher. All the participants had the responsibility to plan, instruct, and assess science standards. In addition to the basic demographic data collected, I also made an attempt to find out whether the participants found the ISTE standards essential when teaching science.

Table 2

Demographics

Participants	District number	Years teaching fourth grade	ISTE standards essential when teaching science (Yes/No)
P1	District 1	2	No
P2	District 1	7	Yes
P3	District 1	3	Yes

P5	District 1	7	Yes
P11	District 1	4	Yes
P4	District 2	3	No
P6	District 2	2	Yes
P7	District 2	5	Yes
P8	District 2	3	Yes
P9	District 2	4	No
P10	District 2	8	Yes

Data Collection

The data collection for this study consisted of 11 semistructured individual interviews with fourth grade science teachers who shared their perceptions of how they are using the selected ISTE standards during science instruction. The interviews were conducted over Zoom, which is a video-based online platform. The interviews were recorded using the Zoom recording capability and I also requested a copy of the text transcript in the Zoom program. Ten of the interviews ranged from 32 to 43 minutes in length, and one interview was 27 minutes in length. Time variation occurred due to the length of participant responses and time differences in follow-up responses as necessary during the interviews. In addition to the interviews, I collected lesson plans from the teachers to analyze their contents. The interviews and analysis of the emailed lesson plans took place over a period of 6 weeks on the Zoom online platform. No participants chose to withdraw from the study.

I emailed consent forms to participants along with the ISTE standards that were selected for the study prior to the collection of lesson plans for analysis and the individual interviews. These consent forms were then signed and returned by the participants through email by stating, “I consent.” In addition to the consent form, participants were provided with a copy of the interview protocol (see Appendix A), which allowed them to review the questions that would be asked during the interview.

During the interviews, I asked participants to share their perceptions of how the selected ISTE standards were influencing their science instruction, the technologies they found most and least innovative and most and least useful, and the supports or resources needed to implement the ISTE standards into science instruction to maximize student learning. All the participants were asked the same questions (listed on the interview protocol) with follow-up and clarifying questions asked as necessary.

The teachers either emailed lesson plans or shared them with me via the web-based program name and specific unit title. I used the lesson plan evaluation form included in Appendix B to check for lesson objectives, student expectations, technologies used in the lesson, digital tools used, and how the lesson was individualized or adapted to meet student needs to maximize student science instruction.

Data Analysis

All of the interviews were recorded on Zoom, a web-based video platform. Following the interviews, I was provided with a copy of the audio transcript of each interview by the Zoom, which I downloaded to a secure, encrypted, removable hard drive. The recording of each interview was listened to so I could clean up the transcription to ensure it matched the contents of the interview and was accurate. A copy of their interview transcript was then emailed to each participant to give them an opportunity to member check the transcript for errors and make sure that there were no discrepancies (see Simon, 2011). I did not receive an email reply indicating incorrect transcripts or requesting any changes to from any of the participants.

The data collection plan outlined in Chapter 3 was completed accordingly with no problems or any other major disruptions. The data collection process (including conducting the interviews and transcribing the data) took approximately 7 weeks and 60 hours to complete. Interviews were scheduled with a 60-minute time limit on the Zoom program. There were no other time constraints, and each interview was completed on time as scheduled. Minor interruptions occurred as most of the participants were at home due to the COVID-19 pandemic, and many of them had young families there.

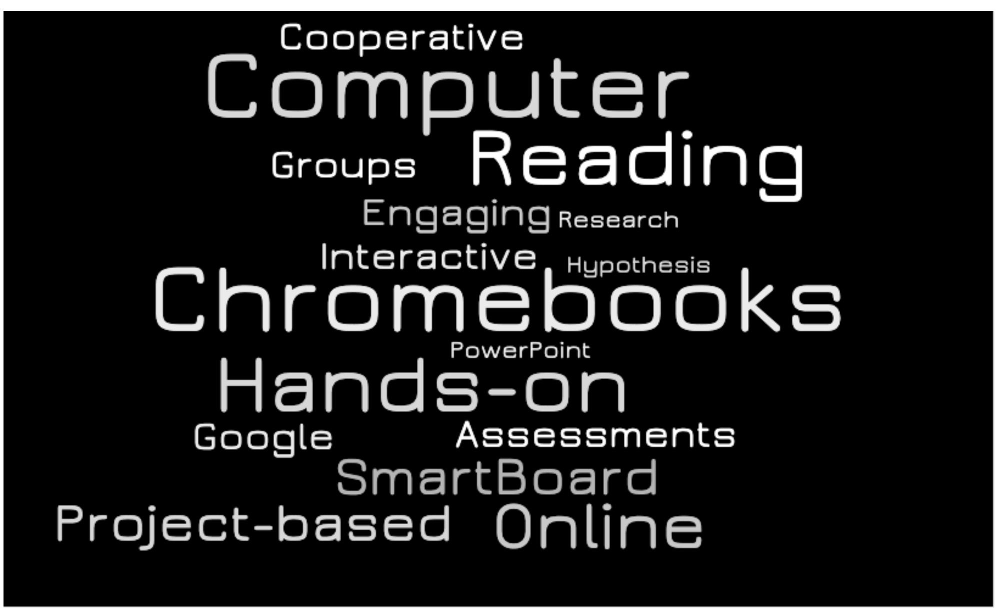
Once the interview data were cleaned up, I printed out and hand coded each of the interviews. Saldaña (2016) described codes as a summary or symbolic representation to a portion of visual data. The first-time coding was to determine the basic codes that emerged from the data. Those key words, or codes, were recorded in an electronic codebook. The second-time coding the data, I compared the codes between each data set to look for categories in the data. The data were coded each time with a distinct and specific purpose to make the process as effective as possible (see Ravitch & Carl, 2016). The common categories and themes were also organized by research question to make the data interpretation simpler.

To gather the basic codes to summarize each line of data, I went through each interview line by line. Some of the codes that repeated frequently were online science programs, such as Mystery Science and Chromebooks. Mystery Science was stated frequently as an online program that was engaging and promoted project-based, interactive student learning. P10 discussed in length the benefits of Mystery Science, saying, "I like Mystery Science it makes science more manageable and engaging. Mystery Science always starts out with a video and it's very interactive because the questions that pop up and those kinds of things." Chromebooks was another code used many times and identified during the initial coding process by multiple participants. P3 was one of the many participants who listed Chromebooks, stating, "I love the Chromebooks that we have, [*sic*] we have the one-to-one Chromebooks."

After completing the hand-coding process, I uploaded the transcripts into the NViVo software program. A word query was then conducted in NViVo with the purpose of looking for the codes that appeared most frequently. Figure 1 is a word map of the most frequently identified words during the query. This confirmed many of the same or similar codes and also revealed others, such as hands-on, research, and hypothesis.

Figure 1

NviVo Word Frequency Query With Most Frequently Identified Codes in the Data



The codes were then organized by research question, following the coding process Saldaña (2016) described after finding codes, categories, and themes. Table 3 shows the codes by the research question and how they were organized. The second step helped to better understand each research question by sorting the categories. Those categories then were looked at in more detail and themes began to emerge.

Table 3

Codes by Research Question

Research Question	Codes from Code Book
What are the perceptions of elementary teachers regarding the implementation and use of the selected ISTE standards when teaching science?	Essential All subject areas Backward planning Google Standards-based curriculum Innovate
In what ways do teachers perceive the three selected ISTE standards to innovate the teaching of science?	Need Chromebooks one to one Coding Computer science standards 21st century skills Necessary Student engagement Manageable Mystery Science –Volcanoes & erosion units Project-based MonoBoards/smartboards
What are teachers' perceptions with the needs of elementary teachers when technology is used in science instruction to maximize student learning?	Learn innovative programs Continue one to one Chromebooks Keeping technology at the forefront Improving technology use Solid curriculum Lack of training Cross-curricular science instruction Collaboration Professional development

When the categories were organized by research question, theoretical saturation began to occur, and themes emerged. Simon (2011) stated that theoretical saturation begins to occur when the coding process is completed using different purposes and strategies. ISTE standards essential or nonessential, online programs, hardware, software, online games, technology as a community, and collaborative learning are themes that were evident and directly related to the central research question regarding the perception of the selected ISTE standards and their use when teaching science. Table 4 shows the categories, and eventually themes, that emerged by the research question.

Overall RQ

Codes that related to the overall research question regarding how the ISTE standards were implemented during teaching science were essential, planning, Google, standards-based curriculum, and innovate. P2 described the importance of technology during science instruction, “Yes, definitely. Technology is a very important part of how I teach science.” “I think what we need is a solid curriculum, and I don't feel like we're there”, explained P3. When conducting the NViVo word query search, all of these words also appeared as frequently found words in the interview transcripts for the central research question, and also the two additional research questions. Innovative technology and innovative practices were the two themes that related to both the codes and categories. “Pretty much every lesson I'm going to create is going to have some type of technology integrated into it,” stated P6. P2 described the importance of technology being essential: “Technology is a very important part of how I teach science.”

Subquestion A (SQA)

Codes that related to SQA, how the selected ISTE standards innovate science instruction, were Chromebooks, coding, computer science, 21 century, necessary, student engagement, Mystery Science, project-based, manageable, and SMART/Monoboards. P3 shared thoughts on both 21st century, coding, and computer science: “Those 21st century learning skills, that is what I am really what I'm trying to do. We're definitely looking into the coding more like how we can know the computer science skills.” After analyzing the codes, categories that emerged were identified from the codes. Figure 2 shows a query done in NViVo analyzing data from participants using the words Mystery Science and Chromebooks. ISTE standards essential or non-essential, online programs, hardware, software, online games, technology as a community, and collaborative learning were categories that emerged from analyzing the data in context with the codes. The following themes were most prevalent: technology, online science instruction, and ease of use of technology.

Figure 2

NViVo Query for Mystery Science & Chromebooks

MysteryScience

Summary Reference

File Name	In Folder	References	Coverage
Teacher-H-	Files	2	0.11%
Teacher-I-	Files	3	0.18%
Teacher-J-	Files	3	0.19%
Teacher-K-.transcript	Files	4	0.07%
TeacherCTranscript	Files	5	0.19%

Chromebooks

Summary Reference

File Name	In Folder	References	Coverage
Teacher-G-	Files	2	0.24%
Teacher-H-	Files	1	0.09%
Teacher-I-	Files	6	0.54%
Teacher-J-	Files	1	0.10%
Teacher-K-.transcript	Files	1	0.03%
TeacherBTranscript	Files	2	0.32%
TeacherCTranscript	Files	6	0.35%
TeacherDTranscript	Files	3	0.16%
TeacherFTranscript	Files	2	0.12%
TranscriptTeacherA	Files	2	0.13%

Note. The participants were saved under pseudo names Teacher A-K during the data collection process in NViVo. Teacher A is P1, Teacher B is P2, and so forth.

Subquestion B (SQB)

Codes that related to SQB, the needs and resources necessary to maximize student learning, were innovative programs, Chromebooks, curriculum, technology at forefront, lack of training, professional development, and collaboration. Equipment needs, professional development, and collaborative teacher support were themes that emerged from the codes and categories for SQB. P7 described some of those needs, “If I think of our teachers as a whole though I would say PD for how to operate the systems such as the interactive board, Chromebooks, and Google Docs and Google Classroom.”

NVivo

Nodes were established in NViVo based on the basic codes that were found during hand-coding, the word frequency query conducted in NVivo, and also one for each research question. A node was created for each interview question, to get even a more in-depth analysis and themes that might emerge not necessarily related directly to the research questions and basic codes.

Table 4

Categories to Themes in the Data by Research Question

Research Question	Categories	Themes
What are the perceptions of elementary teachers regarding the implementation and use of the selected ISTE standards when teaching science?	ISTE standards essential or non-essential Online programs Hardware Software Online games Technology as a community Collaborative learning	Innovative technology use
In what ways do teachers perceive the three selected ISTE standards to innovate the teaching of science?	Hands-on and engaging instruction Online science programs and games, Cooperative and project-based learning Chromebooks™ Interactive classroom screens Open-source processers Science	Most useful technology Online science instruction Ease of use of technology
What are teachers' perceptions with the needs of elementary teachers when technology is used in science instruction to maximize student learning?	Professional development for technology equipment and programs available Professional development for ISTE effective standard integration Providing accommodations to students Collaboration with other teachers Classroom supplies/technologies	Equipment needs Professional development Collaborative teacher support

Data unrelated to the research questions was discovered during the data analysis process, which did not fit into any of the research questions relating to the ISTE standards and science instruction. English language arts programs, STEM teacher/district program, and teaching science through literacy to maximize student learning, and perceived them to increase student science achievement, were the unrelated categories that were evident during the data collection. Although they were not directly linked to the research questions, they will still be discussed in Chapter 5 under future research opportunities.

Evidence of Trustworthiness

Trustworthiness was established by ensuring the data collected was accurate and sensitive to all points of view (Yin, 2016). Understanding and accurately reporting the evidence found in the data established this. Credibility, transferability, dependability, and confirmability were the important factors considered when the trustworthiness of the study was examined.

Credibility

Credibility was given due consideration during the data collection methods. Using multiple data collection methods and collecting more than one set of data established the trustworthiness of data (Patton 2015). Individual interviews, a research journal, and 4^{th} grade science lesson plans were used to help triangulate the data. Conducting semi-structured interviews, which asked the same questions, and helped to establish credibility (Seidman, 2006). In this study, the researcher followed effective interview protocols and consent procedures identified by Shenton (2004) without deviating from them. This increased trustworthiness between researcher and participant, adding credibility to the study. Participants were interviewed following the research plan outlined in Chapter 3.

Transferability

Participants were chosen from districts of varying demographics. Some of the teachers were veteran teachers with 30 years of teaching experience, whereas others were in their first three years of teaching. The setting in which the teachers taught science also varied. Having a diverse population increases the opportunity for the data to be used in future research. STEM is currently receiving much attention in research. Therefore, the results of the study could be used in other studies analyzing student science achievement. The procedures for the study being described step-by-step also increases the likelihood of transferability (Seidman, 2006).

Dependability

For the research to be traceable and documented, the consent form and interview protocol were used prior to conducting the interviews. By using the same protocol procedures and reducing variables that would create interference, I was able to maintain the dependability of the study at a higher level (Flick, 2007). When more documentation and procedures are in place, the study is validated and increases in dependability. By having consent on file and the procedures read to each participant before the interviews were conducted, I made sure that the participants understood the purpose of the study well. The consent form and interview protocol were also mentioned at the start of each interview to make sure that the participants did not have any questions or concerns about the nature and subject of the study, and the types of questions that would be asked. Each participant was asked the same questions following the interview protocol strictly and accurately. This helped to maintain consistency and structure with all the interviews. The lesson plans were all evaluated using the same lesson plan format approved by my research committee which in turn also helped to maintain consistency and structure of the data collection process.

Confirmability

A strategy adopted to maintain confirmability was taking notes in the research journal. Time and date for each interview, district number, total years of teaching, and years of teaching fourth grade were recorded to confirm the data being collected. Confirmability occurred by accurately understanding the participants' perceptions and making meaning of the data (Given, 2008). Member checks were also used to allow the participants to confirm the audio transcripts for each interview. Using a research journal, understanding the participants' perceptions, and conducting member checks helped to establish confirmability.

Results

The results of the study are presented below to help reveal the multiple findings and categorized by research questions and also at times subcategorized by interview question under the correlating research question. This was necessary to show all the findings. The results will explain fourth grade science teacher perceptions regarding the implementation of the selected ISTE standards to innovate science instruction and maximize student learning. Also, the needs and resources perceived as needed to be able and implement the technology effectively.

Overall RQ

What are the perceptions of elementary school teachers pertaining to the implementation of the selected ISTE standards to maximize student learning in science?

Selected ISTE Standards Essential

Out of the 11 participants interviewed, eight of the participants felt the ISTE standards were essential to their pedagogical practices when teaching science.

P11 discussed the importance of technology to the future of our students and indicated that it would be a disservice to the students if technology is not used:

> Yes, particularly just with the push with technology and learning in general and the way science careers are so heavily reliant on technology itself down the road, I think you're really doing a disservice to the students in the long run.

P2 explained how essential the selected standards were to planning science instruction:

> Yes, definitely. Technology is a very important part of how I teach science. We use a program that is all online that has virtual labs and science activities, and I would not know what to do without it. The kids love it, and the program is very engaging.

Other teachers, too, viewed technology as essential, but thought that it was important to all subject areas, not just science as described by P6:

> I would say, yeah, for every subject. Just, I think that a lot of kids relate to... I mean, and then I just think of different teaching, like kids need visuals. And so when I think of technology, I think of like, okay,

> pretty much every lesson I'm going to create is going to have some type of technology integrated into it for those kids who need to see the visual. So I guess I would say they would be essential.

Selected ISTE Standards Not Essential

Three of the 11 participants interviewed thought the selected ISTE standards were not essential to their science instruction for various reasons. According to P9 the statement below indicates her point of view:

> I don't feel like it is essential. From what we've been doing so far and I don't feel like it was essential in our in the curriculum that we chose. I mean, I guess we did use some because we used some pictures and some literature stuff on there. But, and they had a PowerPoint, but that's not really using the technology like that. So, unfortunately, at this point in time, I feel like it’s not probably essential.

P1 talked about how a hands-on, project-based approach is used more:

> I don't really think that they are. I don't know. There's just so many different ways to teach that technology doesn't have to be like most central. Where I start from, especially in science or in social studies is more like project-based learning, per se.

The next interview question that followed helped to understand the central research question. The question asked participants which strategies help to achieve the ISTE standards as essential to teaching science. Many themes emerged from this interview question, which were online programs, hardware, software, online games, and technology as a community, and collaborative learning.

Online Science Programs

There were a few online programs that were discussed consistently among multiple participants, Mystery Science, Discovery Ed Science, and STEM Scopes. P10 explained a few of the benefits of Mystery Science:

> I use a lot of the Mystery Science. Mainly because it was accessible pretty easy to use and you could see that it was hitting the standards and it really provided an opportunity for kids to really be engaged because of the videos and then it actually really was support for myself as well as for the technology component. All I had to do is print off things or, you know, and then it also gave extensions and things that I could use to support student learning. So I found it to be pretty engaging for students.

Discovery Ed Science had similar explained benefits, and P3 described versatility,“But everybody's using Discovery Ed, it's so versatile.

P2 discussed Discovery Ed Science in more detail and some examples for why the program was successful:

> Yes, our science revolves around the program. Probably the most innovative is the program that the students do their science online. It’s super fun and it's a great way to make sure that all the kids are getting what they need and that everything is really clear and they have to

> really think hard, but the end product was really fun and creative and completely individual and it was really neat. One specific one I think of right away is the online erosion simulation. Students get to adjust the factors that could cause erosion and the severity and then visually see what happens and how those erosion factors can impact our earth. Students then get to try and slow down the process through different simulations.

STEM Scopes was another online, free program P3 liked to use during science with her students:

> I love the stem scopes, because the first thing they did is they had an essential learning question. They hooked them in with a short little video and the kids are like, whoa, and then they were talking about it and just, you know, doing background knowledge and getting into it. And so they definitely hook them and get them activating their background knowledge, getting excited about this topic that we're going to be talking about.

P3 discussed the necessity of using multiple different programs and platforms, “It's odd, I guess, but technology for me isn't necessarily a pedagogical strategy. It's a necessity. I'm constantly using different programs and platforms and media to I guess show students how to interact with science.”

Hardware

Reference to multiple types of electronic hardware emerged during the interview questions. Participants mentioned document cameras with projector boards, Apple televisions, Chromebooks, and iPads were all hardware used by students and teachers. P9 discussed the use of the Apple television:

> We have the big 80-inch TVs. And instead of the old Smartboards, just to put stuff up so that everybody can see the same thing or you know, like when reading the books, putting the pictures under there, so they can see it.

P11 also mentioned the document camera use as a strategy, “We have obviously our projector and we have the Apple TV.” Chromebooks™ and iPads were brought up frequently and P4 shared how they are part of everyday instruction:

> I think about pretty much every lesson I'm doing I'm always bringing something up the kids are either doing it on their own on their own laptop Chromebooks or I'm presenting it and we're discussing it. In their Chromebooks and on charts to kind of show that the climate for the year changed. And then we talked, and then we kind of got talking about the idea that, like, well, our climate isn't everybody else's climate, so you know we're going back online to look at historical weather data for Hawaii. And saying, oh, now see, look, they do have differences, but they have a fairly steady claim it, you know, in comparison to ours. We look at that.

P6 also shared ideas about the use of Chromebooks and iPads, “So then the kids have their own Chromebooks, iPads, things like that. And so then they can be interactive.”

Software

The software teachers discussed varied from Google Docs, Google Classroom, Google Slides, and PowerPoint. All of them, except the PowerPoint software, are internet-based software programs. The students were able to access the software from different technology in the classroom during science. P10 discussed PowerPoint slides online:

> Generally, it's a PowerPoint that seems to work out really well. You know, it has to be in a shared document. And so, you know, they have to know all of those components of being able to share documents. Where do you find it? That's been pretty convenient to because it used to be that I have to run computer to computer with flash drive, saving it and then putting it up on the screen.

Similarly, P6 discussed the online software and games used in her classroom, “Yeah. I use a lot of PowerPoint, Google slides, when teaching for that visual…So then the kids have their own Chromebooks, iPads, things like that.”

Online Games

Two of the online games that arose during interviews were Kahoot and Disaster Masters. P6 used Kahoot with her students, “I use things like Kahoot. So then the kids have their own Chromebooks, iPads, things like that. And so then they can be interactive.”

P6 talked about the online game, Disaster Masters:

> I know the engineering practices are one and part of what we were doing. And so it's called Disaster Masters. And the kids can go on this game and they can actually build a city, and then they say there's going to be a tsunami. So they have to get their houses and things ready for the tsunami. So they have to think about how much money they have and how much they want to spend on shoring up houses and things that they want to do. And so that has just been a fun online activity surrounded on all sides by technology and so they get to type and they get to do all kinds of things for that. And so that's been fun.

Technology as a Community

P4 shared her strategy of technology as a community and the importance of making it part of the students' everyday lives, not just as an exciting tool. P4 described that technology is so different today and woven into everything we do and we need to prepare the students for this way of life.

> To show them that science is a community…So technology was not part of my everyday, everyday life. But for them, this is just their life. And our job is not to use it as a hook or as a, you know, as a reward. It's to use it as a way to gather and vet information because that's what they do and that's what they will be doing As they continue to grow up is using technology responsibly and being responsible consumers of what's out there.

Collaborative Learning

Using technology in a collaborative format was also discussed. Collaborative settings using technology can increase engagement and make sure all students are involved in the learning through online software such as Google Docs, Slides, and Classroom. P1 explained how collaborative learning took place during science instruction:

> Definitely cooperative learning for sure I'm, [sic] we are doing it together and you know with groups. Yeah, presenting and starting out with a question. You know, forming a hypothesis, doing the whole scientific methods [*sic*]. Whatever is going to be best for you know your end goal, whether it is a presentation or a science fair.

P10 explained the collaborative benefits of using the online software:

> Generally, it's a PowerPoint that seems to work out really well. You know, it has to be in a shared document. And so they have to know all of those components of being able to share documents. That's been pretty convenient.

Subquestion A (SQA)

The first secondary research question, In what ways do teachers perceive the three selected ISTE standards to innovate the teaching of science was analyzed for themes amongst the data. Many themes emerged as listed in the sections that follow. The themes emerged from the interview questions, which asked what innovative strategies, have been adopted, which most innovative and useful technology affect science pedagogy, and which least useful and innovative technology were used during instruction.

Innovative Strategies Adopted during Science Instruction

Hands-on and engaging instruction, cooperative learning, online science programs and games, Chromebooks, and interactive classroom screens were all discussed when asking what innovative strategies the teachers had adopted during science instruction. P10 described how she used a variety of strategies, including cooperative learning, not only technology based:

> So it's not just everything is technology. You know, there's got to be a whole variety of things. But it's, it is an important component, and it does, give them access to so many different resources. So I think it's important but I think cooperative activities are just as important…and even some independent study where they have to go off and read and learn on their own. So I think that there's just, I think you need to have a variety.

P1 expounded in more detail about cooperative learning strategies adopted during science instruction:

> Everything I do is cooperative learning. Yeah, the more engagement, the better. The closer to you know one to one or one to four, you know, the group work. Usually, you know, more engaging, it's going to keep them involved more. So the further away you get from that ratio, I'd say, you know, the less interactive. The kids are with the

> learning and they have the opportunity to kind of cop out and sit back and just watch and not really be present in the learning.

References to online science games and programs were prevalent throughout. Mystery Science came up multiple times, and also contributed to the cooperative learning theme that emerged. P10 gave examples for how Mystery Science was an effective strategy she uses:

> I like Mystery Science it makes science more manageable and engaging. Mystery Science always starts out with a video and it's very interactive because the questions that pop up and those kinds of things. So I find that to be very helpful. It also sets up activities that are very cooperative where kids have to work together…and that the cooperative end on that…and you can do that pretty easily online. I think the other the other aspect to it is the access to a variety of research component…So I think that's another important thing that technology provides.

Another online science game that emerged was Net Logo. P4 described the benefits of Net Logo:

> I really like to introduce the kids to net logo. It's a very niche sort of program. But it's one of my favorites for younger kids. Because it runs all kinds of simulations and you can kind of get them into coding a little bit because it has open source code.

Chromebooks and interactive display hardware were also noted as innovative strategies adopted during science instruction. P3 had used both during science instruction, "Like we really just use the Chromebooks and the Mondoboard." P9 elaborated on the use of the interactive display hardware:

> So I had this huge TVs and we laughed and said it was like theater seating for the kids, but was easy for them to see an easy for me to use and it made the world of difference between a projector that was put in the wrong spot, you know, because you can roam around or whatever. So it made a world of difference for my kids.

Most Innovative Technology

Many of the same themes were repeated from the previous question about innovative strategies the teachers adopted. One-to-one Chromebooks, interactive projectors, such as the Mondoboard and Apple TV, online computer game simulations, online science programs, cooperative and project-based learning were discussed with very similar responses. Only two new themes emerged from P4--an open-source microprocessor called Arduino, and a science app for the smartphone:

> I've had Arduino for seven years and they're still excellent ways to teach. So Arduino is or a microprocessor. You can attach them to a breadboard. You can attach all kinds of things, but you can attach them to a breadboard to do all kinds of electrical work. And like you can create a Morse code like sender and receiver with them. You can do

> ridiculous things with Arduino and these things are like, this big. I have an app on my phone that's my pedagogy. And that is technology.

Most Useful Technology

Following the discussion about the most innovative technology teachers were asked about what technology they perceived as most useful. Computers, projectors, document cameras, Chromebooks, PowerPoint presentations, display boards and interactive TVs, and student-led research were considered the most useful technologies during science instruction, based on the technology the participants have access to and utilize in their classroom. Many of the comments stated in response to this item mirrored those made earlier during questions about innovative technology and strategies for integrating the ISTE standards effectively into instruction. PowerPoint presentations were more prevalent and elaborated on by P7, as well as student-led research:

> Definitely, the slideshows, and the PowerPoints that have pictures, so that the kids can visualize especially, with the Grand Canyon. Most of them, if not all of them have never seen that. And so they don't have a picture in their head. So it's really, really important that they are able to see it, so they can connect their knowledge to what they're learning.
>
> I think it's great when they are asked to do their own types of research and then use that research and what they're completing… I feel like it's all really important and it all connects to the bigger picture. (P7)

Least Innovative or Useful Technology

A few technologies emerged as being the least innovative or useful in the classroom for science instruction. Least useful specific technologies such as the Smartboard, projectors, and iPods were named. Also, individual, noninteractive technology was mentioned. P6 and P9 both found Smartboards not very useful, and P9 explained that projectors were not very useful:

> I used the Smartboard all the time, and I have not used that really [*sic*]. And I thought it would be something that would be so helpful, but the kids would rather have their own device then go up to the Smartboard and do things like that. So I would say that one has been the least innovative for me. And I've pretty much just used it as a projector…Probably projectors and maybe your Smartboards, just because they're old and outdated.

P1 discussed iPods and technology designed for only one person as being not very useful or engaging: "So just thinking of what resources we have in our school like we have the smaller iPods. I mean those are pretty much obsolete now." Many of the participants, including P2 and P10, did not mention any technology they found least useful or innovative:

> I honestly find all of the technology very useful and innovative that we are using. They used to use carts with computers, and the students would have to share. That would not be very useful for the program I am using. (P2)

> I haven't found anything that I don't use but then I don't feel like that I am the most technologically advanced I always am running to other people would have questions and those kinds of so I'm sure that there are. People are using a much greater variety of technology resources than I am for things. (P10)

Subquestion B (SQB)

SQB, What are teachers' perceptions with the needs of elementary teachers when technology is used in science instruction to maximize student learning? was analyzed through the participants' data. Some of the overarching themes that emerged as teachers' needs to maximize student learning were professional development for the use of technologies, providing accommodations to students, collaboration with other teachers, and classroom supplies/technologies. Technology supports participants needed were professional development and training on technologies provided to them, and also a solid curriculum to use for science. Pertaining to the need for further guidance for implementing the selected ISTE standards teachers indicated that they need more guidance on standards implementation, utilization of effective technology, bringing the standards to the forefront and being more aware of them, and effective collaboration amongst teachers about how they are implementing technology into their science instruction.

Technology Needs to Maximize Student Learning

Participants identified needing a solid curriculum, professional development for the use of technologies, providing accommodations to students, collaboration with other teachers, and classroom supplies/technologies as needs to maximize student learning for science instruction. P3 expressed a strong need for a curriculum to support science instruction:

> I think what we need is a solid curriculum, and I don't feel like we're there. I know that a lot of teachers are really good. You know, like up at the high school level, and even the middle school because they're compartmentalized.

P2 and P7 explained how professional development was needed for both online programs and classroom hardware:

> I actually just got an interactive TV in my classroom that I haven't been able to use yet, but it's, you know, I'm sure you know a great big TV that's better than a Smartboard…so I'm really looking forward to getting to use that…but I definitely need some training on that since I haven't gotten really to use it yet. (P2)
>
> Me personally, I feel very confident using technology…If I think of our teachers as a whole though I would say PD for how to operate the systems such as the interactive board, Chromebooks, and Google Docs and Google Classroom. (P7)

P1 shared that providing accurate accommodations to students was a need:

> The first need that we have is a lot of different ways to provide accommodations for students using the technology. So, some of them might need speech to text technology. Some of the students need

> articles read for them, which if it's on a website. Sometimes that can be kind of tricky or getting like accurate.

P3 and P8 discussed the need and importance of collaboration and sharing ideas with one another:

> It would be nice to know what the other teachers are using and what kind of things are really useful and helpful and cool like what the kids love and what's going to help them the most. So maybe working with some of the other teachers, a little bit more would be really nice. (P3)
>
> I know that a lot of teachers are really good. You know, like up at the high school level, and even the middle school because they're compartmentalized but me as a general ed person I know there are ways there are innovative ways to do it, but I have not had the training or the time to like see [sic] that you know what I mean. (P8)

Classroom supplies and technologies were identified as needs to maximize student learning with technology. P4, P10, and P11 identified specific technology devices for their classroom as their need:

> All right, I need one-to-one Chromebooks. Yes, I need one-to-one devices. I need devices that are at my disposal anytime of day, and I'd really prefer they were if I was going to like have all the money in the world and get whatever I wanted. I would really like touchscreen laptops. I would like I would like the touch screen with the ability to have a keyboard attached, but not necessary. (P4)

Pupil cams and microscopes were explained as technology needed by P10, "I think it's called a pupil cam and it's really just the camera. They use but hook on top of a microscope so that it can project what seen on the screen. That I would like to use."

> You know my teaching partners have the large TV screen kinds of I don't even know what they call them [*sic*], but they look even more interactive than my Smartboard so I would [sic] to have one of those. I would love to have greater access to like an iPad and being able to have lessons prepared and send them up onto the board. I think that I probably could be more technologically savvy. (P11)

Supports Needed to Implement Technology

Technology supports participants needed included professional development and training on technologies provided to them, how to support the idea of phenomenon with better technology, and training on how to integrate more hands-on science instruction. Many of the participants shared that more training on how to implement the technology in science was the support they needed. P8 and P11 shared their training ideas to support the standards and specific terms within the standards, such as phenomenon, more effectively:

> I wish that there were [sic] some teacher training. I mean, I have a huge background in science, and I understand science, and I understand scientific processes, but we are so WyTOPP (Wyoming's Test of Proficiency and Progress) driven and actually trying to figure

> out what I'm supposed to be teaching and what is expected of me to be teaching is kind of a gray area, you know. (P8)

> I know you know the big, the big push with the Next Generation Science Standards with really using that whole idea of phenomena to all the instruction, which I like. I think that's awesome. I think finding the best phenomenon to use and how you that are presented to the kids is really important. And I think that technology can be an important part of that I'm not exactly sure how yet. (P11)

P1 and P4 also discussed the training to support teachers, but explained how technology is constantly evolving, as is the need for more specific training:

> I'm always happy and willing to learn, you know, new types of technology and they're always changing. So any of that PD that you know districts can provide is always really good. Oh, you know there is always more learning. You know, it seems like every time we turn around, we have new computer programs and things that I have to learn, and maybe it's my age, at this point in time, and it’s just not as easy as it used to be. (P1)

> I mean, I think PD around, you know, not as like not a specific platform [*sic*]. But really, how to think about technology integration into your programs. Unfortunately, a lot of times, teachers get PD around like a certain program or certain platform and sure that's great and useful until a year and a half down the road when that program or

> that platform is no longer supported, or now it's not free, the district can't get it…No, we need teachers to be thinking like thinking as technology-driven educators, how can I look for technologies, how can I look for platforms or look for different things that aren't going to be outdated, but around, they're going to continue to evolve as I teach. (P4)

P9 shared that support with online technology, such as Google Classroom, is even more important in today's current situation:

> I've taken some training on my own. But it would just be nice to have district-wide training on how to how to run Google Classroom in case we have to go back to online. I think that would be just more staff to bear more professional development stuff on there.

P3 wanted to learn how to integrate more hands-on science instruction and stated, "How to utilize technology with like hands-on science approaches, like I want to do experiments. I want them to be able to do experiments and do these hands-on things." Although the reasons for the training were all different, most of the teachers expressed some type of training as the support needed to implement the technology in science instruction effectively.

Further Guidance to Implement the ISTE Standards

Participants explained how collaboration with other teachers and sharing ideas, professional development regarding a science program their district is using, internal drive to move with the speed of technology, having a curriculum, and high paced up-to-date technology that matches the ISTE standards. P1 and P11 discussed the importance of sharing ideas and resources with one another to utilize technology more effectively:

> If there's new and, you know, ways that people have done it better and they found other resources just sharing those resources and I'm personally, a person that's not afraid to explore and kind of teach myself how to use them. But there are definitely people out there that are afraid to do that as well. But yeah, I'm always open till learning new and, expanding my repertoire and doing what's going to be I think best for the kids for whatever topic we're talking about. So just keep learning and being willing to have people shared and teaching. (P1)

> I don't think that's a great use of it, and I, I feel like there's probably a way to utilize technology to do a better job of introducing some of these science topics. (P11)

To implement the ISTE standards effectively, professional development is needed. P6 and P9 explained that professional development was needed to learn how to use the tools for science instruction online and with the science program that is available to them.

> I know with this Wit & Wisdom program, there are things I could utilize with that. So I just, I guess that question kind of makes me think of professional development and specific needs for our school. (P6)

> Well, I would just say again, more professional development on how to, you know, on the different tools that are out there and how to implement them for a whole class or even respond groups or whatever.

> It would probably be the most beneficial, maybe just even letting us know of the tools that the district is getting and then training. (P9)

Aside from teacher level collaboration and professional development, another theme that emerged was the necessity to have up to date technology that can also match the ISTE standards and technology that meets those standards. P4, P3, and P7 shared how and why this is important to science education:

> I think that's actually the great mismatch between education and technology is technology moves at ridiculously fast speeds and education just doesn't. We are a very large and old institution right and so you have to have movement from within. It can't be an external stimulus. It needs to be internal propulsion that moves education forward. (P4)

> And again, being able to have I think just again, having a solid curriculum in the first place and meshing being able to match that with the ISTE standards. I think we don't always think about what we aren't doing, you know, there's always room for improvement. (P3)

> I guess I would just want to know if what I'm doing with this or what the students are using technology for is actually meeting that standard if that's enough. Hands-on things for them or if I need to be providing them with more technology opportunities to meet to fully meet the standards. (P7)

Science Lesson Plans Evaluation

During the interviews, participants were asked to share recent science lesson plans that they use. Almost all of the participants either shared copies of the lesson plans, access to the online program they use, or referenced specific lessons from the online program. Using the lesson plan evaluation tool assisted in confirming the use of specific ISTE-related technology and pedagogical practices when teaching science. The following evaluations allowed triangulation of the data and validated statements made by the participants during the individual interviews. Triangulation not only validates the research, but also adds depth to the research (Denzin, 2012).

All of the lesson plans provided by participants used some sort of technology to support the lesson. The lessons were divided into two different types; the first was two online science programs and the other was a cross-curricular lesson where the science was integrated into language arts instruction. Both types of lessons are described more below.

Online Science Program Lessons

Three different online science programs lessons were provided from Discovery Ed Science, Mystery Science, and PhD Science. All three of them were very similar in nature. Each lesson started out with the learning objectives, an essential question the students had to answer, slideshow presentation format, videos embedded in the lessons, and opportunity for students to construct learning through hands-on exploration.

Variety of Technology Resources to Support ISTE Standards

The programs themselves were a technology resource for each science lesson plan taught to the students. The programs are entirely online. The programs provide planning resources, teaching materials, slideshow presentations, video enrichments, and hands-on exploration activities for the students with each lesson, as displayed in Figure 3. The lessons are all prefabricated and provide an estimated completion time range for each part of the lesson. The PowerPoint slide presentation appears to guide the lesson and videos, student checkpoints, and activities are all built into the lesson presentations.

Independent Learning Opportunities

Throughout each lesson, there were checkpoints with questioning, student led activities, and discussions. Students were given an opportunity to work independently or with partners/groups, depending on how the teacher sets up the lesson. How the teacher tracked the learning progress was unclear in the online lessons.

Teacher Named Resources

Whiteboards, PowerPoint presentations, video, and hands-on student learning were named multiple times during individual interviews when discussing Mystery Science, PhD Science, and Discovery Ed Science online K-5 science programs. P7 shared her perspective on PowerPoint presentations, "Definitely the slideshows the PowerPoints that have pictures so that the kids can visualize because, you know, especially with the Grand Canyon."

P1 elaborated on the use of video during the science program instruction, "So I had a video where there were, it was in Miami. They're trying to catch this …they tried all these different ways to capture these monkeys… with different variables."

P10 discussed the cooperative, hands-on components of the online science program:

> It also sets up activities that are very cooperative where kids have to work together. I've also worked on where they've had to do presentations on things. And that the cooperative end on that. I think that anytime that it's not just an individual, but that they're working with a partner or working in small groups and things that facilitate that. And you can do that pretty easily online.

P9 specifically named both Mystery Science and PhD Science as the online programs used:

> We did the electricity one on Mystery Science. So they built flashlights and we also did the marbles and things in there and talk about that first, and the magnets and different ones. The year before we used a lot more Mystery Science. And then the last year the modules from PhD Science.

P2 explained how they use the Discovery Ed Science program, “Probably the most innovative is the program Discovery Ed Science that the students do their science online.”

Summary

In Chapter 4, I discussed the results of a qualitative study regarding teacher perceptions about how teachers are using the three selected ISTE standards to maximize student learning during their pedagogical practices when teaching elementary science. ISTE standards essential or nonessential, online programs, hardware, software, online games, technology as a community, and collaborative learning are themes that were evident and directly related to the central research question regarding the perception of the selected ISTE standards and their use when teaching science.

SQA was designed to help me look for how the selected standards were able to innovate science instruction. Hands-on and engaging instruction, online science programs and games, cooperative and project-based learning, Chromebooks, and interactive classroom screens, and open-source processers were themes that came from SQA. SQB addressed the needs and support teachers needed to effectively implement the selected ISTE standards to maximize student learning. Professional development for use of technologies, providing accommodations to students, collaboration with other teachers, and classroom supplies/technologies were apparent themes in the data.

Themes in the data emerged not directly related to any research question, which were teaching science using literacy and reading instructional time and a district STEM program that does not integrate technology. The chapter also included the setting of the study, demographics, data collection, data analysis, and evidence of trustworthiness. Chapter 5 will include a detailed analysis of the results and how they related to existing literature and the theoretical foundation for the study. Implications for social change, limitations of the study, and suggestions for future research will also be included in the next chapter.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this general qualitative study was to understand elementary school teacher perceptions of how they are using the three selected ISTE standards to maximize student learning during their pedagogical practices when teaching elementary science. During the study, fourth grade teachers shared their perceptions of how the selected ISTE standards were innovating their science instruction. They provided examples of useful and innovative technologies and the needs and support required to maximize student learning in semistructured individual interviews and by sharing their current science lesson plans.

This study contributes to the body of literature by providing an understanding of teachers' perceptions of using the selected ISTE standards to maximize student learning during science. I used a general qualitative design to collect and analyze data from individual interviews with teachers and review of their lesson plans. The data were coded several times, each time with a distinct purpose (see Ravitch & Carl, 2016), analyzed, then cross-compared with the lesson plan data and research journal notes to triangulate the data and validate the findings. The findings from the study revealed:

- Essential technology: Eight out of 11 participants found the ISTE standards and technology essential when teaching and planning science instruction. During interviews and analysis of the lesson plans, the participants shared many aspects as to why technology was important and how it was used during the lessons. The findings indicated that technology continues to be an integral component of student learning, especially during science instruction. This finding confirms the importance of technology and the selected ISTE standards when teaching science.

- Strategies that were identified to support ISTE standards: Online science programs, hardware, software, online games, and technology as a community were strategies identified to support the ISTE standards. The data that emerged during the interview process supported the integration of the selected ISTE standards. Data analysis indicated that online games and programs were also used as strategies to support ISTE standards. In addition, computers were used as a resource to support learning. Previous research supports this finding that online science programs, including hardware, software and online games, can support and maximize student learning in science (Grabau & Ma, 2017).
- The most useful technology: Computers, document cameras, Chromebooks, PowerPoint presentations, display boards, interactive TVs, and student-led research were technologies found to be most useful during science instruction. The access and availability of technology resources, such as computers and hardware, were suggested to have a direct impact on science achievement levels.
- Most perceived innovative strategies: Hands-on and engaging instruction, cooperative learning, online science programs and games, Chromebooks, and interactive classroom screens were perceived as the most innovative strategies. During participant interviews, each of these became evident and

were confirmed during the review of science lesson plans. Ten of the 11 participants provided one or more of the innovative strategies listed above. Participants reported that hands-on instruction through the use of interactive technology and cooperative strategies increases student postachievement in science instruction. The findings provide some insight as to what innovative strategies were perceived to maximize student learning.

- Least useful technologies: Participants named the Smartboard, projectors, iPods, and noninteractive technology as the least useful technologies in science instruction. Lack of resources and resources that do not increase student participation were found to have a negative result on science instruction.
- Need for a solid curriculum and other supporting help: All 11 of the participants identified at least one of the following needs during individual interviews: a solid curriculum, professional development for the use of technologies, providing accommodations to students, collaboration with other teachers, and classroom supplies/technologies to maximize student learning for science instruction. They also desired support to learn about utilizing technology more effectively. In addition, there was an emphasis on additional training on technologies provided to them, how to support the idea of a phenomenon with better technology, and instruction on how to integrate more hands-on science instruction. Teachers who have had professional

development regarding technology during science instruction have implemented the technology more effectively and for longer duration.

Other prevalent facts not related to the use of technology in science pedagogy were discovered in the data. Five participants integrated science instruction through literature and reading instruction. Additionally, three participants indicated that a STEM instructional program, although not technology based, maximized student science learning.

In the next section, I share an interpretation of the results and how the findings of this study confirm, disconfirm, or extend knowledge on the existing literature about academic achievement and science instruction. I also compare the study results with the findings in the literature review in Chapter 2 and the concepts embedded in the conceptual framework. The limitations of the research, implications for social change, and future research recommendations are also provided in the chapter.

Interpretation of the Findings

The majority of participants, 8 out of 11, believe the ISTE standards to be essential to science instruction. This finding aligns with those of Gomez-Arizago et al. (2016) and confirms technology to be not only necessary but also that it contributes to an increase in science achievement levels. The findings of this study extend that knowledge by providing an understanding of teachers’ perceptions and what specific technologies they find to be useful and innovative to science instruction.

Wang (2009) explained the perceived benefits of online gaming science programs and confirmed the perceptions that interactive online science programs and game-type settings are effective and innovative strategies that could be used during science instruction as well as support the selected ISTE standards. Community as a tool for science instruction has also been found to be useful in qualitative and quantitative studies conducted by Shuda et al. (2016) and Whitesell (2016). The findings in the current study also confirm the viewpoint that community is an effective strategy useful in science instruction; however, the findings in the present study contradict Camasso and Jagannathan's (2017) findings indicating that community outreach had no positive impact on science learning.

School resources, such as software and hardware, were identified multiple times during the current study as not only innovative and useful strategies but also as necessary for implementing the ISTE standards to maximize student learning. Provasnik and Malley (2016) also found the availability of school resources affected student science achievement directly. Schools with limited resources, such as computers and other software, had much lower achievement in science than schools with many resources. Both districts in the current study reported having an abundance of resources, including one-to-one Chromebooks, interactive boards, multiple online programs, and a variety of software that includes technology-integrated methods. Although the resources are readily available, teachers are requesting additional support in the form of more training, which would enable them to use the available resources more meaningfully and effectively.

Participants identified professional development as one of the supports needed to implement technology effectively and maximize student science learning with the selected ISTE standards. Several recent studies have identified professional development as a need to integrate technology effectively into science instruction (Son et al., 2016; Zhang et al., 2015). Professional development surrounding technology and science instruction have consistently produced positive academic achievement (Blanchard et al., 2016; Hu & Garimella, 2017). These findings align with the findings of the current study as well. Contrarily, researchers have pointed out that professional development has also been found to create concerns about time and efficacy to implement the technology into instruction (Dailey & Robinson, 2016). No evidence emerged in the current study that supported this contrary notion.

In addition to professional development as a need, teachers also perceived a viable curriculum as a necessary component of effective science instruction, as stated in the literature. Dondlinger et al. (2016) discussed that an adopted, relevant curriculum promoted positive results with the ISTE standards. According to these authors, higher student achievement was obtained when curriculum was adopted with a solid foundation of the ISTE standards. The participants in the current study suggested that teacher training is needed to promote hands-on science instruction. This point was supported by Gomez-Arizaga et al. (2016) and Shuda et al. (2016) who stated that hands-on and project-based science instruction increased both student engagement and student achievement levels.

The theoretical framework of the TAM (Davis, 1985) provided guidance for this study. The model consists of three components: perceived ease of use of the technology, perceived usefulness of the technology, and user's attitude and acceptance (Doulani, 2019). Technology was found to be essential to science instruction, and the research questions aligned with the components of the model. Understanding what the teachers viewed as easy to use and useful as well as their attitude toward the technology can predict whether technology is accepted and has a positive influence during student instruction (Doulani, 2019).

Limitations of the Study

Since the study was conducted in a rural, sparsely populated area of the United States, the participant pool was decidedly limited. Parameters were implemented for the study to have a specific focus (see Simon & Goes, 2011). These parameters, explained in Chapter 3, were aimed at ensuring that the results were valid. However, other factors may have influenced the results of the study. For example, the participants did not all have the same education level in science. Their total number of years teaching science also varied, which may have produced some potential bias or lack of understanding surrounding some science topics.

Implications for Social Change

Teachers' acceptance of technology can positively or negatively impact the use of technology in science education (Grabau & Ma, 2017). Understanding what technologies teachers perceive to be useful and innovative can improve science instruction methods and promote social change for students, schools, and communities. The existing literature has indicated that there is a large need to determine which technologies teachers perceive to be most useful and how they implement the said technologies (Gomez-Arizaga et al., 2016; Son et al., 2016; Tastan et al., 2018). The findings of this study could contribute to preservice educators and science method university courses. Before starting in a classroom, preservice educators could learn which technologies are effective and maximize student learning during science instruction. With the nation as a whole ranking low in science and not implementing technology effectively (NAEP, 2015; USDE, 2017; WYDOE, 2017), the understanding of the effective implementation of technology from districts that are far exceeding state and national averages developed in this study could have a positive impact on the rest of the state and, eventually, the nation.

Recommendations for Future Research

Future research should focus more on the specific technologies perceived by educators as maximizing student learning during science instruction. Many qualitative studies viewed technology as a whole and did not dissect what specifically within technology was making a positive impact. During this study, I took the concepts of perceived ease of use, perceived usefulness, and actual technology use into consideration. Understanding the technologies that participants perceived to have a positive effect on science achievement could help fill a large gap in the literature. Future quantitative or mixed-methods studies measuring the actual student growth and achievement with the perceived useful and innovative technologies in science education could also confirm and/or extend the findings of this study.

A second recommendation would be to replicate the study in a nonrural area with a larger population base. Extending the study from a rural setting to a nonrural setting could strengthen the findings of the study by reaching a larger population and demographic base. The findings could then be compared to the current findings of a rural population.

A third recommendation would be to complete the study again with another grade level measured by achievement assessments. Nationwide and statewide, benchmark grade levels for science assessment are fourth, eighth, and 12th grades. The study could be replicated with eighth or 12th grade science teachers, and findings could be compared to the existing findings of fourth grade teachers' perceptions.

A fourth recommendation would be to complete a study of fourth grade classrooms and look at how science integrated through a literacy program affects science achievement. Teaching science during literacy was mentioned during this study, but the finding was unrelated to the research questions. The study could be qualitative in nature, and compare classrooms where literacy is integrated to teach science versus classrooms where literacy is not used to teach science.

Conclusion

This general qualitative study aimed to understand elementary school teacher perceptions about how teachers are using the three selected ISTE standards to maximize student learning during their pedagogical practices when teaching elementary science. The findings add to the body of literature by understanding what technologies teachers perceive as innovative or useful to maximize student learning during fourth grade science instruction. The TAM (Davis, 1985) effectively guided the researcher to understand how the technology user perceives the usefulness, ease of use, and actual use of the technology. This data can be a broad indicator of whether or not the technology is implemented effectively.

Findings have indicated that the participants view the selected ISTE standards as essential when teaching science, but also have identified many specific technologies as innovative, most and least useful, and supports to be able to maximize student learning. Since educators often do not implement technology effectively, and technology has been found to increase student achievement in science, understanding what teachers perceive as effective could help other educators within the state and nation to maximize student learning during science instruction. Research has confirmed that determining what technology is useful and utilized during science instruction is necessary to increase student achievement in science and maximize student learning (DeCoito & Richardson, 2018).

Online science programs, specific hardware, software, online games, hands-on project-based learning, science through literacy, and additional STEM instruction, were identified as innovations utilized to maximize student learning. Online student learning and hands-on, engaging science instruction utilizing technology, has been found to increase science achievement (Baturay et al., 2017; Gyamfi, 2017; Ha & Lee, 2019; Teeroovengadum et al., 2017). Technology resources can also lead to increased achievement in science, and contrarily lack of resources can decrease student achievement levels (Provasnik & Malley, 2016). By understanding how teachers are utilizing the three selected ISTE standards during their pedagogical practices when teaching science, student learning can be maximized giving other teachers, schools, and districts an opportunity to increase student science achievement.

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Appendix A: Interview Protocol and Interview Questions for Teachers

Interview Protocol

Demographic Data

Name: ___________________________ Age: ______________

Years Teaching: ______________ School: ____________________________

Opening Statement

Thank you for meeting me today to discuss how teachers' perceptions of the implementation of the three selected ISTE standards affect their pedagogical practices of teaching science. Before we begin, I will be asking you to sign an informed consent that you are volunteering willingly to be part of my study and be interviewed.

I will be conducting interviews of other teachers in the two school districts where you are located. Your participation is entirely voluntary. At any time during the interview you may opt out of the interview or decline to answer a question. Each interview will be video recorded and audio recorded as backup. You will be provided a copy of the transcript and be asked to ensure that the transcript is an accurate description of what you said during the interview. This is called member checking and is a way to confirm accuracy during the study.

All personal information, including your lesson plans, will be safe guarded for security and deleted off my personal computer and placed on an encrypted removable hard drive until the study is completed. The information will not be shared with anyone not part of the study.

Rapport Building Questions:	i. Tell me about your journey that has brought you to the current setting you are teaching at? ii. Do you enjoy teaching? iii. How long have you been teaching? iv. How long have you taught at your current elementary school? v. What are your favorite subjects? Is science one of them?
Interview Questions for Overall RQ: What are the perceptions of elementary teachers regarding the implementation and use of the selected ISTE standards when teaching science?	1. Do you perceive ISTE standards as essential when teaching science? 2. Do you use any specific pedagogical strategies to achieve the above objective? 3. What innovative strategies do you

	adopt? 4. Do you feel that the three selected ISTE standards influence your pedagogical practices of teaching science? 5. What specific types of ISTE related technology do you find the most innovative? 6. How does the implementation of the ISTE related technology affect your pedagogical practices?
Interview Questions for Sub RQA: In what ways do teachers perceive the three selected ISTE standards to innovate the teaching of science?	7. What specific types of ISTE related technology do you find most useful? 8. What specific types of technology do you find the least innovative? 9. What specific types of technology do you find the least useful?
Interview Questions for Sub RQB: What are teachers' perceptions with the needs of elementary teachers when technology is used in science instruction to maximize student learning?	10. What needs do you have to maximize student learning with technology? 11. What additional supports do you need with technology? 12. Do you feel that you require more guidance to implement the selected ISTE standards to maximize student learning? If so, what are those needs?

Closing Question

Today we talked about how elementary school teachers' perceptions of the implementation of the three selected ISTE standards affect their pedagogical practices of teaching science. Are there any other question(s) I should have asked that I did not?

Thank you again for being willing to participate in the interview. Upon receipt of the transcripts, you make any corrections at that time.

Appendix B: Lesson Plan Evaluation Tool

Question	Researcher Comments
What are the objectives of the lesson?	
What is the topic of the lesson?	
1.What are the variety of resources used by the teacher when teaching the lesson that would align with the selected ISTE standards chosen for the study? a. digital tools b .creative artifacts c. What were the expectations from the students?	
2. What kind of technology usage is planned in the lesson to a. create b. adapt c. to give learning experiences to the student	
3. Did the lesson plan provided provision foster independent learning among students?	
4. Did the lesson plan made any provision to accommodate learner's differences and needs?	
5. Has the teacher named the digital tools and resources, which would help to maximize active deep learning among the students?	