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Teacher Perceptions of Teaching Science Using the 5E Instructional Model

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This dissertation has been read and approved as fulfilling the partial requirement for the Degree of Doctor of Education in Curriculum and Leadership.

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Dedication

I would first like to give honor and praise to my Lord, my God, my savior and redeemer. Thank You God for giving me the strength to endure even during my worst of times. Thank You God for continually growing me into the transformative leader you have called me to be. I dedicate this prestigious work to my dearly beloved sons, Maliyk and Mekihi for playing a major part of me becoming the woman I am today. Maliyk, may you continue to rest in heaven with our heavenly father. Mekihi this is definitely for you. You have seen me through my good and bad times, you have encouraged me to keep pressing and striving to be great in life. My sacrifices, your sacrifices were so worth this. I pray that this is the beginning of something greater for us.

To my spiritual father, Victor L. Powell. Thank you for your obedience of hearing the word of God that confirmed that Mekihi and I both would have doctorate degrees. For your leadership, your wisdom, and your guidance. Thank you for being a sound voice in my ears. To Dr. Shereca Harvey and Amie Henry, thank you for your wise counsel and mentorship, I am forever grateful. To my sister and friend, Tierra Brown-Ward and Shaneka Davis-Winston, Thank You! Thank you for accepting me for who I am without judgement or shame and being the support I didn't know I needed. Thank you all for keeping my hands lifted and not letting me throw in the towel.

Lastly, to every student that I have ever taught or impacted your life in one way or another. For many of you know my story, many of you know my journey. Let this be an example to you that nothing is impossible, no matter where you've come from, what you have and don't have, or how hard life may get…. Change The Narrative! Continue to work hard and endure to the end

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Abstract

Changes made to science education on the national level caused many changes for state education systems. In the state of Georgia, science education instructional leaders also saw the need for a change in the way science needed to be taught to students. Due to the need to improve science teaching and learning and to increase interest in the STEM fields, Georgia Standards of Excellence for Science were released in 2016. Science teachers were required to shift their instructional practices to teach science as a practice by engaging students in specific tasks aligned to science and engineering practices. This study focused on the perceptions of middle and high school science teachers about the implementation of the 5E Instructional Model in science education. Perceptions conceptual frameworks were used in a cohesive approach to understand the experiences middle and high school science teachers had toward the implementation process of a new instructional strategy. A qualitative descriptive study was conducted to capture teachers' perceptions of the 5E Instructional Model and its impact during their instruction. To obtain descriptive data, virtual semi-structured interviews were conducted. Purposive sampling was used to recruit eight middle and high school science teachers. Interviews were transcribed and coded, then findings were organized into themes. Three major themes derived from the descriptive data were: (1) Provided Structure to the Teaching and Learning Process; (2) Required More Time to Develop and Implement Lessons; (3) Provided Student Centered and Hands-On Instruction. The researcher discussed the implications of the study, disseminated the findings, and provided recommendations for future studies.

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CHAPTER I: INTRODUCTION

Background of the Problem

Since the 1950's, there have been educational and curriculum reforms aiming towards improving science education. The launching of Sputnik I in 1957 was a reminder to the United States as to how far behind they were in science education (Wissher, Concannon, & Barrow, 2011). The United States feared that graduates lacked mathematical and scientific skills needed for the country to improve with technological advances. Serving as a catalyst for several innovations and reforms for science education in the United States, the launch of Sputnik brought about immediate changes to science education (Nelson, 1997).

During the presidency of Ronald Reagan in 1983, many studies began to surface about the academic underachievement in the United States. The National Commission on Excellence in Education produced *A Nation at Risk: The Imperative for Education* (U.S. Department of Education, 1983) which opposed several of Reagan's policies in education. Warning of a national education crisis, various reports issued over the next few years supported the commission's conclusions from *A Nation at Risk* and resulted in a call for action (Nelson, 1997).

A Nation at Risk (1963-1980) reports implied that the national math and reading scores had not had any significant growth. For most, this was an indictment for complacency for all educational officials, stakeholders and the American public (U.S. Department of Education, 1983). It was realized that the United States was not only "A Nation at Risk," but there was definitely more work to be done. In response to "A Nation at Risk," The National Research Council (NRC), the National Science Teachers

Association (NSTA), the American Association for the Advancement of Science (AAAS), and Achieve worked together to rewrite science standards and curriculum in the United States (NRC, 2012). All of the previously mentioned organizations became partners in developing Next Generation Science Standards. The development of these standards involved the input of numerous science teachers and many other stakeholders (National Research Council, 2012).

Performance standards for science education are one of the guiding instruments used to describe what students should learn in schools (Nelson, 1997). Performance standards are used to guide teachers' content for teaching while using multiple instructional practices (Georgia Department of Education, 2014). Over time, science education standards have been reconstructed to meet the academic needs of the students of the 21st century. Education in the 21st century includes students with diverse needs who require diverse instructional practices in order to be academically successful. A challenge for 21st century educators is meeting the needs of all the diverse learners who share a single classroom (Hadjioannou, Hutchinson, & Hockman, 2016). Teachers who lack proper preparation and support to meet the needs of diverse learners have feelings of frustration and discouragement (Koch, 2020).

To effectively address the diverse needs of all students, teachers need to concurrently address challenges and barriers to meeting the academic needs of all students (Parrish, 2019). Students learn differently from each other, but also students might learn differently from day-to-day based on their own feelings and emotions (Weissberg, 2016). The research of (Marzano, 2001) indicated that the effects of well-prepared and instructionally sound teachers on student achievement can be stronger than the influences of student background factors.

After full review of research-based strategies that help students to learn science effectively, the authors of *A Framework for K-12 Science Education* (National Research Council, 2012) articulated a new vision for K-12 science education. This new vision for science education encouraged a shift from traditional approaches in science teaching and learning to approaches that applied more practice in what was being taught and learned (Pruitt, 2014). Science and engineering practices, crosscutting concepts, and disciplinary core ideas (DCIs) were presented as the necessary components of the new conceptual framework for science education (Duncan & Cavera, 2015; NRC, 2012). These practices required teachers to implement more application and "doing" in science rather than students merely learning facts (Bybee, 2011). These practices served as a model for science teachers to construct lessons to ensure that students know and understand science content and can apply the knowledge and skills to new situations (Duncan & Cavera, 2015).

In 1996, the National Science Education Standards outlined what students needed to know, understand, and do to be scientifically literate. The standards were developed to increase students' scientific literacy at all grade levels. However, they were replaced in 2013 with the Next Generation Science Standards (National Research Council, 2013). This began the process of change once again in the instructional practices for science education, but this time the change would implement more practice into science teaching and learning.

Next Generation Science Standards

The establishment of Next Generation Science Standards (NGSS) has taken science education to another shift in education. With the adoption of NGSS, traditional approaches to teaching and learning science have to shift in order for students to learn science effectively (Lom, 2012). The purpose of the adoption of NGSS was to develop critical-thinking skills, scientific literacy, and increased interest in STEM education in American students (National Research Council, 2013). The need for more application in science education and not just memorization, is evident through the objectives identified in the NGSS. The NGSS represent a move towards solving problems using scientific thought and design thinking (Bybee, 2011). This framework is called the three-dimensional learning model.

With the establishment of the NGSS and the need for more applications and experience in science education, teachers have to implement new instructional practices to improve science achievement (National Research Council, 2013). Curriculum developers have attempted to identify research findings they can incorporate in materials that will facilitate connections between teachers, the curriculum, and students (Stabback, 2016). In science education, the use of learning cycles and instructional models have become common (Withers, 2016).

The continual use of an effective, research-based instructional model can help students learn fundamental concepts in science and other domains (Bybee, et al., 2006). Using the NGSS and 5E Instructional Model (5E model) together provides teachers with the key components of science learning and assessment of student performance (Ashbrook, 2017). The 5E model is based upon one used in the creation of the Biological

Sciences Curriculum Studies (BSCS) materials which implement theories of the constructivist teaching model (Bybee et al., 2006). The 5E model consists of five learning phases. Each phase has a detailed framework which is used to aid students' understanding of science by "providing more application in the way students learn science, providing critical thinking, phenomena and real-world experiences" (Tanner, 2010).

5E Instructional Model

In the 1980s, the 5E model was developed by the Biological Science Curriculum Studies (BSCS) and consists of five phases of learning: engagement, exploration, explanation, elaboration, and evaluation. These phases are described as follows:

1. Engagement: the teacher activates or hooks the students' prior knowledge,
2. Explore: students are given the opportunity to explore the topic being taught through "hands-on" and "minds-on" experience,
3. Explain: students communicate what they have learned and make meaning of their learning. The teacher clears up any misconceptions,
4. Elaboration: students bridge together connections between prior knowledge and new experiences, and
5. Evaluation: the teacher uses formative or summative assessments to assess the students' learning (Bybee, 2014, p.10-13).

The 5E instructional model and constructivist learning methods have been shown to be effective in student learning and development of critical thinking skills (Ergin, 2012). There were few prior research studies on the preparation needed for teachers to implement the 5E instructional model. In one study of implementation of science teaching based on the 5E instructional model, researchers aimed to enhance the knowledge of how teachers understood and implemented the 5E instructional model (Skamp & Peers, 2012). The study was based on feedback provided from teachers who had tried Primary Connections units and suggested that brief professional development about the 5E model will not necessarily lead to effective use as an instructional practice. Researchers analyzed the teachers' feedback to see if it reflected an understanding of the embedded 5E model. Many teachers' understanding of the 5E model varied in each of the phases depending upon their understanding of the model. Although none were reported, the study suggested that teachers could possibly experience negative reactions towards new pedagogies (Skamp & Peers, 2012).

Statement of the Problem

Studies on STEM reform indicated that there are challenges and barriers to implementing reform in science education (Dancy & Henderson, 2008). In particular, implementation of the 5E Instructional Model may not be effective due to factors such as lack of teacher training, instructional resources, and support (van Garderen, Decker, Juergensen, & Abdelnaby, 2020). Recommendations made by the National Research Council (NRC) required science teachers to shift their instructional practices to teach science as a practice by engaging students in specific tasks aligned to science and engineering practices (NRC, 2012). Students in each grade level were expected to master specific grade-level appropriate capabilities before exiting the academic grade level. Changes made to science education on the national level caused many changes for state education systems as well. In the state of Georgia, science education leaders also saw the need for a change in the way science needed to be taught to students. In 2016, the state of Georgia began its work to develop the Georgia Standards of Excellence for Science

(GSE). This work entailed a restructuring of the Georgia Performance Standards into the GSE to provide more of a practical approach to science learning. The new GSE for Science included 3-D Model Learning, Crosscutting Concepts, Phenomena, and the use of the 5E Instructional Model (National Research Council, 2013). It was expected of science teachers in the state of Georgia to implement these instructional strategies in the 2017- 2018 school year. Considering the timing of events that has caused a shift in the way science is taught, the researcher would like to determine the impact of the 5E Instructional Model on science instruction in a Northeast Georgia School District.

As Georgia school districts began to adopt the Standards of Excellence for Science, there was no definitive "how to" in terms of teaching science, and many were given the autonomy to deliver science instruction in their own way (Duschl & Grandy, 2010). A local school district in Northeast Georgia named the Excellence School District, decided to take on the use of the 5E Instructional Model to deliver science instruction to all middle and high school students. Through the use of the 5E model, students were taught to use scientific practices, disciplinary core ideas, and crosscutting concepts to explore, examine, and explain how and why phenomena occur and to design solutions to problems.

To reduce barriers to achievement for the students in the Excellence School District, teachers needed to be able to implement instructional practices in science. To help address this issue, a Train-the-Trainer model was used, and science department representatives in the school district were trained in the use of the 5E Instructional Model. During the training, participants experienced 5E lessons as if they were students in order to learn what should be done during actual implementation. Science department representatives then redelivered the training to science teachers in their departments at their schools. There was no evaluation on teachers' use of the 5E model, and it continued to be a part of the curriculum provided to teachers from district instructional leaders. The researcher felt that this study was viable because oftentimes teachers are required to implement various instructional practices without enough time to actually train and effectively implement the new strategy before moving to something else. Understanding that the need to improve science teaching and learning is critical, if those who are responsible for helping this improvement take place are not adequately prepared, then science education will still be at a disadvantage.

Purpose of the Study

Considering that training and implementation of the 5E model took place after the start of the 2017-2018 school year, the researcher proposed to study teachers' perceptions of the impact of the 5E instructional model on their classroom instruction. The researcher wanted to examine the perceptions of middle and high school science teachers in regard to the implementation of the 5E Instructional Model. The researcher used purposive sampling to select middle and high school science teachers for participation in an interview for a qualitative descriptive study of teachers' perceptions of the 5E Instructional Model and its impact during instruction.

Research Questions

The goal of the study was to examine the perceptions of middle and high school science teachers in regard to the implementation of the 5E Instructional Model. The study was guided by three main research questions to achieve the primary goal of the study:

RQ1: To what extent do middle and high school science teachers perceive that the use of the 5E Instructional Model impacts their classroom instruction?

RQ2: To what extent do middle and high school science teachers understand the purpose of learning and teaching science through the implementation of the 5E Instructional Model?

RQ3: To what extent do the perceptions of middle and high school science teachers differ in regards to implementation of the 5E Instructional Model?

Conceptual Framework

For the purposes of this study, the researcher focused on perceptions of middle and high school science teachers where the 5E Instructional Model was being used, to determine how the instructional model impacted the teachers' classroom instruction.

Teacher Perceptions

Perceptions are the thoughts or mental images teachers may have. Their perceptions are shaped by their background knowledge and life experiences (Rahimi & Rajaee, 2015). Perception relates to how one reacts to situations or one's behavior towards a situation. A person comes to "know" or better understand his/her own attitudes and behaviors by observing self-behavior and the situations in which those behaviors occur. One's self-actions are interpreted the way other's actions are interpreted. A person's actions are socially influenced and not produced out of free will as expected (Bem, 1972).

Individuals sometimes do not have internal access to the causes of their own behavior (Grabe & Hyde, 2007). Nisbett and Wilson (1977) summarized several studies that show how people often do not have accurate knowledge of why they behave the way they do. Similar deficits were observed in connection with why people feel the way they feel and how certain factors affect their moods (Grabe & Hyde, 2007).

Teachers' perceptions are thought by many researchers to be an essential component to consider when seeking change in pedagogical practices (Gentry, Baker, Lamb, & Pate, 2016). Teachers' perceptions about science, teaching science and learning science directly influence their classroom decisions and actions about teaching science (Busher & Tas, 2012). Participants' interactions, past beliefs, cultural histories, experiences, and perceptions are all part of the process of learning.

The Implementation and Perceptions Framework

The Implementation and Perceptions Framework, displayed in Figure 1, is a visual representation of the research purpose and research questions. The purpose of the study was to investigate the perceptions of middle and high school science teachers about the impact of the implementation of the 5E Instructional Model on classroom instruction.

The top circle represents the first research question, "To what extent do middle and high school science teachers perceive that the use of the 5E Instructional Model impacts classroom instruction? The bottom circles represent the second research question, "To what extent do select middle and high school science teachers understand the purpose of the learning and teaching of science through the implementation of the 5E instructional model?" In Figure 1, the circles form a Venn diagram, which represents the similarities and differences in the levels of concern about the 5E Instructional Model and impact on classroom instruction as reported by middle and high school science teachers in the study.

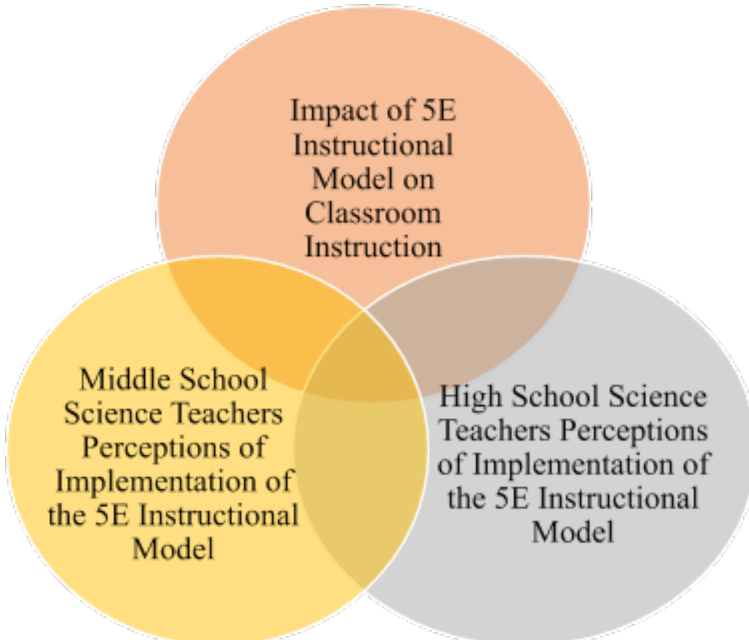

Figure 1. Implementation and Perceptions Framework

The conceptual framework is established on the perceptions and understanding of teachers implementing the 5E instructional model in science instruction. The perceptions of middle and high school teachers will be analyzed to determine if teachers perceive that it has an impact on their classroom instruction. The differences in perspectives of middle and high school teachers will also be analyzed to determine if perceptions had an impact on the implementation and use of the 5E model. It is important to compare and contrast the perceptions of middle and high school science teachers to determine if there are similarities or differences that can help make a connection for effective use of the instructional model.

Methodology Overview

The researcher proposed to conduct a qualitative descriptive study, examining perceptions of middle and high school science teachers employed in one Excellence School District. Data were gathered concerning the perceptions of select science teachers regarding the impact of using the 5E Instructional Model on science classroom instruction. The qualitative approach was the best fit for this study because the researcher wanted to capture perceptions and give voice to those involved in the implementation of the 5E Instructional Model in a way that uncovered concerns to implementing the practice (Sutton & Austin, 2015).

A purposive sample of middle and high school science teachers was used in this study (Creswell, 2009). The researcher chose this sampling method because it uses specific criteria to select those participants to provide insights into the phenomenon being examined (Creswell, 2009). For the purpose of this study, middle and high school science teachers were defined as teachers who provided instruction to students in grades 6-12 using the approved Georgia Standards of Excellence for Science during the 2018-2019 school year in Georgia. All teachers who participated in the study shared the same 5E Instructional Model implementation methods and training provided by their school district. The researcher obtained permission from the superintendent to conduct the study with middle and high school science teachers within their school system.

The researcher contacted by email, science teachers at each of the district's middle and high schools and gained consent to set up individual interviews. The initial email contact to each principal included a description of the study as well as a link to a digital informed consent form. Principals who agreed to have their science teachers participate clicked agree and entered their email address as an electronic signature. Science teachers interested in participating in the individual interview were given informed consent forms electronically and asked to sign and set up a date, time, and location for the interview.

The researcher used a semi-structured interview guide approach, which allows participants to explain in detail and elaborate on views and perceptions, and the researcher to gather in-depth rich details important to the study (Sutton & Austin, 2015). These perceptions were organized into categories and themes based on responses. Themes were used to draw conclusions or make generalizations that informed the researcher of the perceptions about implementation and impact of the 5E Instructional Model. The interviews were recorded and transcriptions sent to participants for member checking. To establish the validity of data collected from the individual interviews, the researcher used a reflection journal and transcripts of interviews to verify accuracy of each participant's responses.

Delimitations and Limitations

The researcher conducted the study in the Excellence School District. The participants were chosen using stratified purposive sampling to include those with first-hand knowledge of teaching using the 5E Instructional Model. When training was provided for the 5E Instructional Model, it was after the 2017-2018 school term had already begun. Science teachers were used as participants in the initial 5E Instructional Model training. Training at each middle and high school was through redelivery from their representative science teacher.

The study was limited by the truthfulness and honesty of the participants. The study was also limited by the personal biases of the researcher and the location of the study being in one school district in rural Georgia. The researcher had no knowledge of any of the teachers having been trained in 5E Model in another school system prior to implementation in the selected school district. The researcher had no knowledge of how thoroughly the trainers implemented the 5E Model with the teachers in the schools. The researcher had no knowledge of how effectively the teachers employed the 5E Model in their classrooms.

Delimitations were the choices made by the researcher describing the boundaries set for the study. The geographical location of the study was chosen for personal interest. The researcher made connections with many of the faculty of the schools in which the study was conducted. These connections benefited the study by increasing the response rate and willingness of participants to be involved in the individual interviews. These relationships may have increased or decreased the honesty of the answers obtained to questions in the study. To ensure honest feedback, the researcher ensured the confidentiality of each study participant and ensured them that their identity would not be disclosed.

The study was delimited to one school district in rural northeast Georgia. This study is delimited to only those teachers who went through the training provided by the district in 2017-2018. The study was delimited to only those full-time classroom teachers who were employed during the 2018-2019 school year and those middle and high school teachers who taught science courses approved by the Georgia Department of Education for the years of the study. No attempt was made to contact any teacher who might have participated in the training but is no longer with the school district to participate in the study.

Definition of Terms

5E Instructional Model: A research-based instructional strategy including the phases Engage, Explore, Explain, Elaborate, and Evaluate, steps which educators have traditionally taught students to move through in phases (Bybee, et al., 2006).

Excellence School District: pseudonym for the researched school system in Southwest Georgia.

High School Science Teacher: a teacher who provided instruction to students in grades 9-12 using the approved Georgia Standards of Excellence for Science during the 2018-2019 school year in Georgia.

Middle School Science Teacher: a teacher who provided instruction to students in grades 6-8 using the approved Georgia Standards of Excellence for Science during the 2018-2019 school year in Georgia.

Perceptions: A mode of capturing reality and experience through the senses, therefore allowing discernment of figure, form, language, behavior, and action (Given, 2012).

STEM education: "STEM education is the intentional integration of science, technology, engineering, and mathematics, and their associated practices to create a student-centered learning environment" (FDOE, 2018).

Three-dimensional learning model: A framework that consists of science and engineering practices, crosscutting concepts, and disciplinary core ideas.

Significance of the Study

The findings of this study will benefit the science teachers, principals, science coordinators, and others who are impacted by the change in the science curriculum and how science is taught. The researcher has been affected by this shift in instructional practices and wanted to explore the perceptions of other science teachers in the Excellence School District, who completed their true full year of 5E instructional model implementation in the district in 2018-2019. The science curriculum coordinator believed that the study would benefit by assisting science teachers in the district to better implement the instructional model and by providing support to teachers where needed. The 5E Instructional Model is required to be used consistently amongst all academic grade levels in science in the district, yet the study could suggest implications for curriculum support and professional development.

Summary

Curriculum, pedagogy, and practices tend to change periodically, and the goal is to have effective change. Understanding teachers' perceptions about implementation of change and new instructional strategies is essential because their perceptions influence their decision making and implementation of new instructional strategies (Given, 2012).

Teachers in the selected school district began implementing the 5E Instructional Model after the 2017-2018 school year began. The 2018-2019 school year made it more of a full term to examine the attitudes and perceptions of teachers using the instructional model. The researcher used the qualitative descriptive study approach to investigate the perceptions of middle and high school science teachers in regards to implementation of the 5E Instructional Model.

CHAPTER II: REVIEW OF LITERATURE

The chapter is divided into three main sections. The first section, Historical Perspective of Science Instructional Practices, provided a context for understanding the need and purpose for the 5E Instructional Model which helped provide insight into teachers' perceptions of the model. The second section, 5E Instructional Model, provided a background perspective on what the 5E model was and its purpose for being used in science instruction. Teachers' Perceptions of Educational Reform, provided a perspective for understanding why teacher perceptions are valuable in providing insight to educational reform. Science education has gone through countless educational and curriculum reforms. The launching of Sputnik was a reminder that the United States was not preparing students for a technical workforce. Instead, students were just memorizing facts and not learning to apply science to real-life situations (Bybee & DeBoer, 1994).

Historical Perspective of Science Instructional Practices

Science curriculum developers, policymakers, and teachers have continuously worked to improve instructional practices that will increase, enhance, and promote greater outcomes for student learning in science. After World War II, there was a substantial amount of pressure to improve science teaching in the United States (Waldrop, 2015). Efforts for improvement were documented as early as the 1950s and 1960s after the launch of Sputnik and the subsequent realization of the United States' inability to compete with other countries in science education.

As a direct result of the United States' inability to compete with other countries, several educational reforms were initiated to improve science education. After a failed attempt to launch satellites in response to the launch of Sputnik I, many national science educational programs were developed (Wissher, Concannon, & Barrow, 2011). These educational programs were developed in an attempt to encourage science education in the United States. Programs such as Biological Science Curriculum Study (BSCS), Earth Sciences Curriculum Project, Introductory Physical Science, Chemical Education Materials Study, Intermediate Science Curriculum Study, and Physical Science Study Committee were all developed in the 1957-1976 timeframe, all with intentions to enhance science teaching and learning in many facets (O'Hearn, 1966).

During the presidency of Ronald Reagan in 1983, the National Commission on Excellence in Education produced *A Nation at Risk: The Imperative for Education* which opposed several of Reagan’s policies in education. The report implied that improvements in education were needed to address concerns about content standards, teaching and leadership, and fiscal support. The purpose of the study was to generate reform of the educational system and to renew the nation’s commitment to schools and colleges of high quality. The study examined the conflicting demands that were placed on the nation’s schools and colleges that were exacting an educational and financial cost. The report described how America's educational system was failing to educate students well and recommended that schools become more rigorous, that they adopt new standards, and that teacher preparation and pay be evaluated (National Commission on Excellence in Education, 1983).

The American Association for the Advancement of Science (AAAS) was deeply involved in the science and mathematics reforms developed after the launching of Sputnik. The published report of AAAS, *A Benchmark for Science Literacy (1993)*, also known as Project 2061, was developed with the purpose of providing assistance to teachers in guiding students to achieve science literacy upon the completion of high school. The report was a set of specific K-12 learning goals and reform tools to help educators select and create instructional materials, assessment instruments, and professional development (Nelson, 1997). Since 1969, the National Assessment of Educational Progress (NAEP), also known as the Nation's Report Card, has measured what United States' students know and can do in various subjects. According to the data analyzed through NAEP starting as early as 1971, science and mathematics progress had steadily declined from an already unacceptable level (U.S. Department of Education, 1997).

The National Research Council (NRC) played a significant role in the development of the National Science Education Standards (NSES) in 1996. The goal was to improve science education instruction by limiting the number of core disciplinary ideas taught. Science was divided into three major areas: science and engineering practices, crosscutting concepts, and disciplinary core ideas. The NSES called for changes in six sectors of the education system that would be required to realize sustained improvements in student performance:

- Teaching
- Professional development for teachers
- Assessment
- Content
- Science education programs
- Science education systems (NRC, 1996).

Evaluations of Project 2061's impact and influence were conducted where 20 educators were arranged to assess the report for adherence to national standards and benchmarks. The Stanford Research Institution (SRI) International, which is an institution specializing in conducting research and development for the government, reported that there were common gaps in framework documents provided by Project 2061. The frameworks did not include major content areas and simplified concepts. Equity issues were also reported due to the lack of tangible examples of how the state would guarantee science literacy for all students (Organization for Economic Co-Operation and Development, 2012).

After Project 2061, President Bill Clinton unveiled his educational reform strategy during the State of the Union Address in the year of 1999. Clinton's plan requested that Congress use federal funding to support what would work to improve education in the United States (Organization for Economic Co-Operation and Development, 2012). Clinton had six elements he wanted to be attached to the educational federal dollar which were…

- To end social promotion
- To reform or close low performing schools
- To establish teacher qualifications
- To involve parents
- To receive district issued report cards
- To implement a discipline policy for students

President Clinton's educational plan was not accepted by Congress and many Republicans; however, in 2001 President George W. Bush signed into law the No Child

Left Behind Act. Bush's plan had similar core elements to that of Clinton's (U.S. Department of Education, 2002; Grasta, 2008).

After the signing of No Child Left Behind (NCLB), the effort to improve public schools increased (Dee & Jacob, 2010). NCLB legislation required states, districts, and schools to enable students to receive an appropriate education and for states to test student academic achievement. As defined by NCLB, an appropriate education is an educational right of all children in the United States guaranteed by the Rehabilitation Act of 1973 and the Individuals with Disabilities Education Act (IDEA) (U.S. Department of Education, 2002).

The Math and Science Partnership Program (MSP) of 2002 became the next initiative to improve science education. The National Science Foundation (NSF) and NCLB efforts to build capacity in the STEM discipline were through the Math and Science Partnership Program. The program's purpose was to improve student outcomes and reduce achievement gaps in science and mathematics. The program increased funding in education to aid in training teachers to teach science and math more effectively and provided lab kits and enrichment programs (U.S. Congress, 1958).

In a three-year timeframe, *Tapping America's Potential* (2005) became the next initiative for improving science education. The United States' ability to sustain its scientific and technological superiority became a great concern for 15 businesses. These businesses decided to collaborate to help maintain the country's ability to compete in the 21st century and to assist in doubling the number of STEM graduates with bachelor's degrees. It was decided that science and mathematics education had to be improved to keep the United States from enduring a 21st century version of Sputnik (U.S. Congress, 1958).

The progress education had made since the publication of A Nation at Risk in 1983, was evaluated in the 2008 report, A Nation Accountable (U.S. Department of Education, 1983). Shortly after, the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Reauthorization Act was passed in the year 2010. The Act was originally signed in 2007 to promote better science education in the United States. The act was created to encourage education in STEM fields and to make it a priority in the United States. This act was yet another initiative of NCLB through the former President G.W. Bush. It was President Bush's goal to enable students to graduate high school fully prepared to enter college or the workforce in STEM fields (President's Council of Advisors on Science and Technology, 2010).

In 2012, the National Research Council (NRC) published A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. The goal was to improve science education instruction by limiting the number of core disciplinary ideas taught. The framework included an overarching theme of making science instruction relevant to students' lives. In the *Framework* (NRC, 2012), researchers acknowledged that many science teachers were not prepared to engage students in the style of teaching and learning demanded by the science and engineering practices. Students were learning too many facts instead of experiencing science in a practical way.

In 2013, the National Science Education Standards established in 1996 were replaced with the Next Generation Science Standards (NGSS), which were based on the

National Research Council's (NRC) recommendations in A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012). Stakeholders from 26 states and various facets of science education worked to develop the science education standards (National Research Council, 2013). The team assisted with the science reform by creating the Next Generation Science Standards (NGSS). All who had a stake in science education were afforded an opportunity to inform the development of the standards. This resulted in well-defined, college-and-career-ready K–12 *Next Generation Science Standards* ready for state adoption (National Research Council, 2013).

The Next Generation Science Standards framework addressed the concerns of teaching science as a practice through the use of a three-dimensional learning model. The three dimensions are as follows: (D1) scientific and engineering practices, (D2) crosscutting concepts that unify the study of science and engineering through their common application across fields, and (D3) core ideas in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science (National Research Council, 2012).The establishment of Next Generation Science Standards (NGSS) led to another shift in science education with the purpose to develop critical-thinking skills, scientific literacy, and increased interest in STEM education among American students (Kelly & Knowles, 2016). The Next Generation Science Standards (NGSS) focused on adding more application and critical thinking from engaging, hands-on, relatable activities in science (National Research Council, 2013).

New Approach to Teaching Science

The federal government felt compelled, after the launching of Sputnik, to act upon the lack of preparedness of the United States by initiating curriculum reform through the National Science Foundation (U.S. Congress, 1958). Since the late 1800s until recently, how science should be taught has been of great concern. The National Research Council (NRC) was founded in 1916 to assist the National Academies of Science, Engineering and Medicine with research to form policies among the many science and engineering fields. In the 1950s and 1960s, improvement efforts for technological and scientific developments in science education were initiated (NRC, 2012). National science programs were developed in an attempt to enhance science education in the United States (Bybee, 2009).

Publication of *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (*Framework*) (NRC, 2012), provided a comprehensive, research-based foundation for the revision of science standards by drawing on current research about the way students learn science effectively. The goal of the three-dimensional model is to transform the focus of the science classroom to environments where students use disciplinary core ideas and crosscutting concepts with scientific practices. These three dimensions are to be used to explore, examine, and explain how and why phenomena occur and to design solutions to problems (Duncan & Cavera, 2015).

When implementing science and engineering practices, teachers should combine core disciplinary ideas and cross-cutting concepts which are appropriate for students' designated grade levels. The Framework (2012), which provided the foundation for the

NGSS, identified eight practices for science and engineering essential for all students… These practices are detailed below.

Asking questions and defining problems. Students at any grade level should be able to ask questions about their learning (NRC, 2012). This is the beginning stage of science and engineering. Asking questions and defining problems includes students asking questions about data, claims that are made, and proposed designs.

Developing and using models. Modeling begins in the earlier grade levels. Students begin with the use of pictures or physical scale models and matriculate to the use of more abstract representations in later grades (NRC, 2012). Models do not correspond to the real world, but they do however help to bring focus to various learning, showing students that there are limitations when developing questions and explanations.

Planning and carrying out investigations. Students should have opportunities to plan and carry out different kinds of investigations during their K-12 learning experience. At all levels, students should engage in investigations developed by the teacher and those that are developed from the students' own questioning (NRC, 2012). It is certain that teachers will have to develop some investigations because some investigated topics are topics students would rarely care to investigate on their own. Science then becomes a learning experience where students practice more than memorization and rhetoric.

Analyzing and interpreting data. Students are expected to collect data from their investigations in order to identify any patterns and relationships. Data collection should also allow students the opportunity to communicate findings and results with other students and even their teachers. During this practice, students are expected to be able to organize and interpret data through tabulating, graphing, or conducting statistical analysis (NRC, 2012).

Using mathematics and computational thinking. Mathematics brings science and engineering together by enabling engineers to apply the mathematical form of scientific theories and by enabling scientists to use powerful information technologies designed by engineers. The performance expectations of this practice require students to construct simulations, solve equations, apply quantitative relationships between variables to predict the behavior of systems and test the validity of such predictions (NRC, 2012).

Constructing explanations and designing solutions. The performance expectations of this practice are intended to engage students in constructing theories and proposing solutions to problems that can be tested using criteria (NRC, 2012). Constructing explanations requires cognitive engagement, reflection, and self-correction by students (Davis, Summers, & Miller, 2012).

Engaging in argument from evidence. The expectations are that science and engineering should produce a sense of the process of argument, which is necessary for advancing and defending a new idea (NRC, 2012). Students are expected to use evidence from claims and argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits when conducting investigations, testing solutions, resolving questions, and creating models (NRC, 2012).

Obtaining, evaluating, and communicating information. Expectations are that science and engineering are needed to develop students' ability to read and produce domain-specific text. Students are expected to obtain, evaluate, and communicate information based on the students' need to be able to read, interpret, and write scientific and technical text, communicate clearly and persuasively, and evaluate the merit and validity of claims, methods, and designs (NRC, 2012).

Each practice described above was designed to align the performance of the students in the science classroom to the practices of scientists and engineers. The science and engineering practices are performance expectations described for students by their academic grade level, K-2, 3-5, 6-8, and 9-12 (NRC, 2012). As a student matriculates grade levels, the complexity and sophistication of the performance expectations increase, expecting more or a step further in the learning task (NRC, 2012).

Educational leaders in the State of Georgia committed to the work of implementing the science and engineering practices as one of the 26 lead states (National Research Council, 2013). After numerous opportunities for revisions and review, the Georgia Standards of Excellence for Science were adopted by the State Board of Education in March 2016 (Harvey, 2017).

Teachers were expected to teach the Georgia Standards of Excellence for Science by integrating the three-dimensional learning model, incorporating content related to specific learning progressions, and connecting the standards to Science, Technology, Engineering, and Mathematics (STEM) and literacy (Evans, 2013). In April 2016, the Georgia Department of Education's Science Ambassador Program was enacted to support the implementation and professional development needs associated with the new approach to instruction (Harper, 2019). Although the State of Georgia did not adopt the Next Generation Science Standards, its framework addresses the objectives from usage of the three-dimensional learning model (NRC, 2012).

5E Instructional Model

In *Democracy and Education* (1916), John Dewey supported placing the child, not the curriculum, at the center of the classroom. Dewey saw education as a social interaction between children and adults. He believed that knowledge could not simply be given to a child but that a student must experience something and engage with it to learn (Twyman, 2016). John Dewey believed that students' learning experiences should be more than just "hands-on." Students should experience science through a process similar to the scientific method. Students are given the opportunity to define a problem to solve. After defining a problem, they should make a hypothesis, conduct observations, evaluate the observations, and test the hypothesis. In this particular learning cycle, students should follow the described process which was considered to be "hands-on." After completing the "hands-on" step, the students should use a step called "minds-on" to reflect on their experience (Brown & Abell, 2007).

In 1962, Atkin and Karplus argued that effective learning cycles involve three components which are exploration, term introduction, and concept application (Tanner, 2010). Through the development of the Science Curriculum Improvement Study (SCIS), they created the original learning cycle that became widely recognized for teaching inquiry-based science (Atkin & Karplus, 1962). The original learning cycle model was grounded on the ideas and work of Johann Friedrich Herbart, John Dewey, J. Myron Atkin and Robert Karplus (Bybee et al., 2006).

In the Science Curriculum Improvement Study's model of the learning cycle, exploration allowed the learners to become interested in the subject at hand, raise questions, and identify points of dissatisfaction with their current understanding (Tanner, 2010). There is integrity in each phase of the 5E Model to allow opportunity for students to practice science, and the sequence of the model should be followed to maintain its effectiveness (Bybee, 2014). Teachers tried to omit and shift the order of the model, which led to reduced effectiveness in the learning process (Tanner, 2010).

In the beginning of the 20th century, Herbart developed a philosophy of teaching that consisted of two main components: conceptual understanding and interest. Herbart's philosophy was one of the first approaches to teaching similar to a learning cycle (Hanuscin & Lee, 2008). The term "learning cycle" in this research is defined as a sequential process designed for teaching and learning (Marek, 2008). Students would be given the opportunity to discover first and then build on prior experiences and knowledge. To further the students' connections, teachers would guide their students through most experiences. Teachers would explain the expected outcome for students through their learning experiences and allow students to apply new knowledge to their new experiences. Herbart proposed that if a student could explore and discover science concepts, he/she would have more understanding and knowledge (Bybee, et al., 2006).

The 5E Instructional Model (further called the 5E model) was developed in 1987 by the Biological Science Curriculum Studies and consists of five phases of learning: engagement, exploration, explanation, elaboration, and evaluation. The 5E Model is grounded on the constructivist approach where learning is an active, contextualized process of building knowledge rather than gaining it (Richards, 2015). Knowledge is built based on personal experiences. The learning built in the 5E model becomes more personalized to students through the use of phenomena and completing each phase of the model allows students to practice science as they learn (Bybee, et al., 2006).

The 5E model has been used in various science curricula and has been widely applied in education (Hu, Gao, & Liu, 2017). Through the 5E model, students and teachers are allowed to engage in the learning and teaching experience by building upon prior experiences and knowledge to create meaning and to frequently assess learning and understanding of what is being taught (Ergin, 2012).

The engagement phase is where the teacher activates or hooks the students' prior knowledge. The intentions of the engagement phase are to promote curiosity and elicit prior knowledge which causes the students to explore conflicts or problems. The exploration phase should be hands-on where students inquire and investigate a phenomenon in order to generate new ideas. After exploration, students proceed to the explain phase. The explanation phase is a combination of student and teacher responsibilities. Students are responsible for explaining their understanding of the concept, and the teacher's responsibilities are to introduce concepts and skills. In the elaboration phase, students' understanding and skills are extended through new experiences with the concept. The evaluation phase is another student-teacher combination task. Students are responsible for assessing their own understanding and abilities, while the teacher evaluates the students' progress toward meeting learning targets (Hu, Gao, & Liu, 2017).

Bybee (2014) suggested that the best use of the 5E instructional model is a unit of two to three weeks, using each phase as the basis for one or more lessons. Using the model for a single lesson decreases the effectiveness of the individual phases due to shortening the time and opportunities for challenging and restructuring of concepts for learning (Bybee, 2014). Using the model for an entire program would maximize the time and experience of the individual phases; however, the expectation for student experiences and outcome of the phases loses its effectiveness if not used in its entirety (Bybee, 2014).

Keeping the need to increase student achievement in science in mind, early designs of the BSCS 5E instructional model were to serve as an instructional sequence that would help teachers approach instruction in a meaningful way. Within the science education community, the model has been recognized for its practical value and incorporated into school programs, state frameworks, and national guidelines (Bybee, 2014).

Effects of Implementing the 5E Model

In a study to determine if the 5E model improved the instructional processes of novice teachers, researchers used 40 novice teachers as participants. The participants all had chemistry backgrounds and were selected from China, Hubei, Henan, and Inner Mongolia. The participants underwent a series of instructional activities based on the 5E instructional model, and these activities were observed and measured through participatory cooperation for four months. Participants also completed questionnaires. The researchers collected the participants' instructional process test which was related to their instructional design process at different stages based on the model. The tests were divided into three groups: before instruction, immediately after instruction, and 3 months after instruction. The researchers then analyzed each test comprehensively to extract the relevant content and data points. An evaluation of the instructional design at each phase of the 5E model was made, and novice teachers were evaluated at each. Out of the 40 original participants who volunteered for the study, the researchers choose three participants to study closer. The three teachers were all novice, with different educational backgrounds, years of working, and current working conditions. The study indicated that the 5E model can produce sustained influences on the teaching process and improvements in the instructional design process. Researchers suggested that the main reason for this observed improvement was that the 5E model provided an ideal outline for the design of instructional processes (Hu, Gao, & Liu, 2017). The study also indicated that the 5E model can improve novice teachers' awareness levels with respect to the many aspects of instructional design (Hu, Gao, & Liu, 2017).

In a study of extended worksheet development according to the 5E Instructional Model (Toman, Akdeniz, Cimer, & Gurbuz, 2013), researchers aimed to develop worksheets about ethanol fermentation that were effective in using the 5E model approach. Researchers used each phase of the 5E model through worksheets to examine the extent of student success from learning through worksheets and actual exploration. The researchers also wanted to identify the effects of the use of worksheets on learning in educational environments. Researchers interviewed four teachers who were named as "experts" in their field of study and assessed 28 second-year students in the Science Teaching Department of Bayburt University. The 28 students were given an achievement assessment developed from the goals and objectives of the topic chosen from the curriculum (Toman, et al., 2013). The expert teachers discussed the assessment with researchers, who then made any adjustments to the delivery of the 5E Model subject matter recommended by the teachers. Once complete, the 28 students were given worksheets and an additional assessment to compare with the previous assessment data.

The results of the study were that the rate of student success increased by more than half from the pre-assessment to the post-assessment, after the worksheets and practice on ethanol fermentation took place. Worksheets that included attention grabbing activities different from traditional content, increased student success in learning about ethanol fermentation. Researchers suggested that worksheets based on the 5E model constructivist approach enabled students to actively participate during the learning process, helped them to learn subject matter better, and increased student success (Toman, et al., 2013).

In a study of the effects of teaching with the 5E model on students' behaviors and conceptual changes, the misconceptions of eighth grade students related to heat and temperature were investigated (Turgut & Gurbuz, 2011). The study aimed to compare the effectiveness of the 5E model and traditional instruction on eighth grade students' understanding of heat and temperature concepts. Thirty-seven eighth grade students participated in the study. Participants were in two different classes and taught by the same teacher during the same school year. One of the classes was randomly selected where students were taught by means of activities which were prepared according to the 5E model. The other class was used as the control group in which students were taught by traditional methods (Turgut & Gurbuz, 2011).

A three-phase Heat and Temperature Misconception Test (HTMT) and the Attitude Scale towards Science and Technology (ASST) were used to collect data. The data were analyzed using independent and a paired sample t-test. Results of the Heat and Temperature Concept Success Test indicated that the 5E model was more successful on remediation of misconceptions. Results also indicated that the 5E Model was more effective in providing a permanent conceptual change than the traditionally designed instruction (Turgut & Gurbuz, 2011). However, there was no statistically significant difference between the experimental and control groups in terms of students' attitude towards science and technology (Turgut & Gurbuz, 2011).

In a study of using the 5E model to study the concept of magnetic hysteresis curves in physics, the effects of the 5E Model on students' understanding of concepts related to magnetic hysteresis curves were explored. Researchers explored the implementation of the 5E Model for concept formation of 120 students from two higher secondary schools of the district of Mardan in India. The concept formation method of teaching was compared with the traditional method of teaching through the 5E model and student's conception and understanding of magnetic hysteresis curves in physics. Researchers used a pretest and posttest for the collection of data. One of the classes were randomly selected as experimental group in which students were thought by means of activities which were prepared according to the 5E model, and the other was determined as the control group in which students were thought by traditional methods. Based upon the data from pre- and post-assessments, the results suggested that the concept formation method of teaching using the 5E model was more effective as compared to traditional methods of teaching (Shah, Muhammad, Abubaka, Khalid, & Uzma, 2019). Results indicated that students in the experimental group had an alternative conception on the concepts related to magnetic hysteresis curves that was an improvement to their previous conceptions (Shah, et al., 2019).

Personalized Learning

The implementation of the 5E Instructional Model is based upon cognitive psychology, constructivist-learning theory, and best practices in science teaching (Duran & Duran, 2004). Learning through the use of the 5E Instructional Model allows students to have a personalized learning experience because students change their initial concepts through self-reflection, elaboration, redefinition, and reorganization (Bybee, 2009). The process of the 5E model gives students more ownership of their learning, and they are able to internalize their own interpretations of the learning based on their conceptual understanding.

In the 18th century, schools with one classroom and one teacher existed all across the United States. As the country transitioned from the one room schoolhouse to grading schools, it was assumed that children of the same age could learn the same materials at the same pace (Gundlach, 2012). Teachers have long recognized that the prior knowledge and experience students arrive with on their first day of school varies greatly. Teachers have used numerous strategies to address the needs of children who may be the same age but are at different learning levels (Josephson, Wolfgang, & Mehrenberg, 2018).

Personalized learning models seek to adjust the learning experience of students based upon their strengths, needs, and interests (Herold, 2017). In practice, personalized learning is used to describe everything from supplemental software programs to whole-school redesigns. It should encourage students to become more responsible for their own learning. Personalized learning is a supporting guide to aid teachers in maximizing student achievement (Easley, 2017).

According to Johns (2018), there are four core elements of personalized learning: (1) flexible content and tools, (2) student reflection and ownership, (3) data-driven decisions, and (4) targeted instruction. Johns suggests that educators should approach each core element to personalized learning as a spectrum. Each core element should be implemented one at a time in order to fully maximize the use of each, which will result in incorporating all four within learning in a meaningful way.

Developing flexible content and tools involves teachers mixing three different instructional materials in personalized learning. Teachers should use materials that are adaptive, customizable for individual students, and foundational (Johns, 2018). Adaptive content provides students with practice opportunities at an appropriate level of challenge. Customizable content provides teachers the opportunity to author and curate original content, while also giving students new platforms for collaboration and demonstration of knowledge. Foundational content provides a core set of concepts and exercises guaranteed to all students (Johns, 2018).

Student reflection and ownership strategies are to promote ongoing student reflection and ownership of learning (Johns, 2018). Teachers should provide ample opportunities for students to reflect on their learning and their success. This includes setting goals, monitoring progress, and choosing learning activities. It is suggested that students gain more ownership over their learning through this core element of personalized learning.

Data driven decisions are the decisions made by the teacher based upon student work collected such as assessments, projects, and performance-based tasks. Consistent data collection helps to inform teachers on instructional decisions and grouping of students. This is also a task open to students, giving students the opportunity to review their own data and make learning decisions (Johns, 2018). Giving students a role in the data driven decision-making process further gives them ownership of their learning experience.

Targeted instruction for personalized learning allows teachers to create and change student groups based on student interest, need, or skill-level. It minimizes the whole group structure and targets specific student groups or skills to better meet the needs of students. The small groups aid the teacher in differentiating by using various strategies, such as grouping students with homogenous skills so teachers can focus their lessons or heterogeneous skills to encourage collaboration (John, 2018). Teachers have strived to meet students' individual needs by including their interests and preferences into instruction. Personalized learning can be viewed as an all-inclusive school wide assimilation of these ideas across all grades and subject areas (Pane, 2018).

The implementation of personalized learning allows teachers to shift educational approaches. Bray and McClaskey (2013) defined personalized learning environments as learners actively participating in their learning. Learners are given a choice and a voice in how they demonstrate what they know from the learning experience. Learners own and co-design their learning. The teacher is a guide to the learning that takes place. Students are required to take increased responsibility for their learning (Bray & McClaskey, 2013).

In a qualitative study to analyze approaches to goal setting in middle grades personalized learning environments, researchers used a 30-60 minute semi-structured interview to investigate the goal setting approaches of 11 middle grades teachers. In the state of Vermont, this was the first year of a statewide personalized learning implementation. During the interviews, participants completed a task sheet where they ranked the relative importance of different inputs into the goal-setting process. Some of the interview participants volunteered additional goal-setting artifacts from their classes.

The interview transcripts served as the primary data source, while the task sheets and auxiliary artifacts served as supplemental data sources. Researchers suggested there was an urgent need for empirical research in this area and that goal setting was a critical aspect of personalized learning (DeMink, Carthew, Olofson, Leopros, Netcon, & Hennessey, 2017). Researchers found five dominant trends in teachers' approaches to goal setting which were independent design, interest driven co-design, interest and skill driven co-design, skill driven co-design, and selection. Data collected from the semi-structured interviews showed that personalized learning has the potential to provide equal educational opportunities for all students. Schools in the United States are implementing personalized learning as a way to meet diverse interests, needs, and abilities of students (DeMink, et al., 2017).

In a study of students authoring personalized "algebra stories," the role of situational interest in personalized learning was examined. Bernacki and Walkington (2018) examined whether personalizing four algebra units for the problems high school students solved could improve their performance on classroom and unit assessments. In the study, 155 high school math students in multiple classes taught by two different teachers participated in solving personalized algebra problems to determine if results would show greater situational interest than peers who solved standard algebra problems.

Students from classes covering the whole Algebra I curriculum within the school year (n=77) and those covering half the curriculum (n=73) were included in the study. Five students were removed because their data from the intelligent tutoring system logs could not be matched to the data provided by classroom teachers and administrators. After experimentation, 150 high school students reported on a survey, greater situational interest in algebra units than those who completed standard algebra problems. Data showed personalization had a significant impact on the latent mean level of triggered situational interest across the four units ($\beta = .169$, $p = .025$). There were also indirect effects of personalization on maintained situational interest related to enjoyment ($\beta = .145$, $p = .026$) and value ($\beta = .098$, $p = .032$) (Bernacki & Walkington, 2018). The study suggested that contextualized personalized learning that is integrated with student interests into the learning tasks in classrooms positively affects student achievement in math (Bernacki & Walkington, 2018).

Teachers have strived to meet students' individual needs by including their interests and preferences into instruction. Personalized learning can be viewed as an all-inclusive school wide assimilation of these ideas across all grades and subject areas (Pane, 2018). The 5E model can serve as a catalyst during student learning to promote personalized learning. The 5E model promotes collaborative, active learning in which students work together to solve problems and investigate new concepts by asking questions, observing, analyzing, and drawing conclusions (Duran, 2003).

Teacher Perceptions of Educational Reform

Teachers' perceptions are some of the most significant factors that affect the teaching and learning process (Elmas & Aydin, 2017). Individual beliefs tend to influence teachers' actions, which will affect their classroom instruction (Williams & Burden, 1997). Teachers' perceptions alter the perceptions of the learners, the learning atmosphere and learners' attitudes towards learning (Elmas & Aydin, 2017).

In a quantitative study of enhancing school to home communication through Learning Management System (LMS) adoption, the perceptions of teachers were examined to determine the impact of using a LMS for school-home communication. The study was conducted in a rural Michigan school district with 84 teachers in the school system. The researchers used a 19-question survey to examine teacher perceptions. The survey was composed of Likert Scale questions and open-ended questions. Quantitative data were analyzed using SPSS, and a descriptive analysis was conducted to view the overall trends in responses (Laho, 2019).

A constant comparative method was used to analyze the open-ended responses for recurring patterns and themes. Of the 84 teachers selected to participate in the study, only 66 teachers responded to the survey. Data showed that 85.3% of teachers were comfortable with using technology to communicate with parents and that they perceived the adoption of the LMS to have high benefits for school-home communications (Laho, 2019). The researchers suggested that the use of teacher perceptions can sometimes mitigate results because teachers' perceptions of reported actual behaviors may differ from their actual behavior (Laho, 2019). Respondents sometimes provide responses that they feel are socially desirable.

In a study of teacher perceptions of Performance Evaluation Systems (PES), a survey of teacher perception was administered in a large Midwestern United States school district (Finster & Milanowski, 2018). The district piloted the new PES two years prior to the administration of the survey. The survey was administered in the spring of the first full year of full implementation of the new PES. The new PES was implemented in response to a change in state laws for educator evaluation measures. The data collected from the internet-based survey were a part of an evaluation of the implementation. There was an 80% response rate which equaled 12,292 educators across 515 schools. The survey had 26 survey items designed to measure the perceptions of teachers on various aspects of the PES. The survey items were on a Likert scale ranging from 1 to 4 (Finster & Milanowski, 2018).

To analyze the results of the internet-based teacher survey, researchers used Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) to identify hidden factors of teacher perceptions of evaluation and to examine the relationships between the multiple hidden factors. The CFA model identified eight factors and also indicated that all of the factors were moderately to strongly relate to each other. Standardized factor loadings ranged from .40 (relationship between Evaluator Credibility [factor 3] and Understand Measures [factor 1]) to .97 (relationship between Impact on Teaching [factor 6] and Impact on PD [factor 5]). After testing the theoretical constructs using the CFA, the validity of a causal structure was tested using SEM (Finster & Milanowski, 2018).

The SEM model indicated that teachers' understanding of the evaluation measures (F1) had a direct effect on teachers' perceptions of the measures' fairness (F2), which had a direct effect on the perceived credibility of evaluators (F3). Teachers' perceptions of the measures' fairness (F2) and evaluators' credibility (F3) had a direct effect on teachers' perceptions of the quality of the feedback received from evaluation process (F4). Teachers' perceptions of the measures' fairness (F2) also had a direct effect on future choices and activities for PD (F5) and collegiality (F7). Teachers' perceptions of the quality of the feedback received as part of the evaluation process (F4) and influence on PD (F5) had a direct effect on changes in teaching practices (F6). Changes in teachers' practices (F6) and collegiality (F7) had a direct effect on overall perceptions of the benefits of the PES (F8) (Finster & Milanowski, 2018).

The structural model parameter standardized estimates ranged from 0.18 (F6 on F4) to 0.86 (F7 on F2). Measure Fairness (F2) was directly significantly related to multiple other factors, including Evaluator Creditability (F3) (STDYX standardized coefficient = 0.63, SE = 0.01, $p < 0.001$), Feedback Quality (F4) (STDYX standardized coefficient =0.34, SE = 0.01, $p < 0.001$), and Impact on Collegiality (F7) (STDYX standardized coefficient =0.86, SE = 0.01, $p < 0.001$). Regarding the Impact on Teaching (F6), the standardized path coefficient value is larger for Impact on PD (F5) than for Feedback Quality (F4) (STDYX standardized coefficient = 0.85 versus .18). This indicated that PD choices and activities were more strongly associated with changes in teacher practices than direct feedback as part of the PES. Also, the Impact on Collegiality (F7) had a larger standardized (STDYX) regression coefficient (0.62) on Evaluation Benefits (F8) than Impact on Teaching (F6) (standardized (STDYX) regression coefficient = 0.22), which indicated there were changes in collaboration and communication (Finster & Milanowski, 2018).

In the establishment of new practices, researchers suggested teacher perceptions of the quality of various reform efforts are critical for making implementation work effectively (Finster & Milanowski, 2018). To implement the PES, it was considered critical that teachers perceived the multiple measures as fair, valid, and reliable. In addition to having trained evaluators, teachers should perceive that their evaluators are knowledgeable, credible, and fair (Finster & Milanowski, 2018). The study suggested that teacher perceptions have a great deal of influence on the outcomes researchers may be seeking in the implementation process of new practices for change (Finster & Milanowski, 2018).

In a study identifying barriers inhibiting inquiry-based science teaching and potential solutions, the perceptions of 34 teachers were analyzed. The teachers were part of a large-scale Australian high school intervention project based around astronomy (Fitzgerald, Danaia, & McKinnon, 2019). In a series of individual semi-structured interviews, the teachers identified a number of common barriers that prevented them from implementing inquiry-based approaches. The researchers used open-ended questions to interview teachers about inquiry-based science teaching. Two methods of analysis were used. The first analysis was a traditional coding approach as an exploratory analysis while the second used Leximancer as a confirmatory analysis to identify any potential personal bias arising from using the first approach (Fitzgerald, Danaia & McKinnon, 2019). The study identified barriers to implementation of new practices which included time restrictions, the poverty of common professional development experiences, lack of good models and definitions, and the lack of good resources enabling the capacity for change (Fitzgerald, et al., 2019).

Science Teachers Concerns and Preparation for Educational Reform

Teachers go through different Stages of Concern (SoC), ranging from giving low priority to reform in the unconcerned stage to being engrossed about how they can improve the innovation in the refocusing stage (Gudyanga & Jita, 2018). Differences between how policymakers envision the implementation of reforms and teachers' actual implementation have been of concern to researchers (Priestly & Drew, 2016). Research has shifted from a focus on teachers' failures and resistance to taking into consideration teachers' needs, sense making and concerns (Priestly & Drew, 2016). Researchers considered it progressive for policymakers to acknowledge these concerns as it demonstrates respect for teachers (Gudyanga & Jita, 2018). The Concerns Based Adoption Model provided researchers a useful framework for supporting teachers in implementing new instructional practices within the school setting (Gudyanga & Jita, 2018).

In a study of physical science teachers' concerns regarding the Curriculum and Assessment Policy Statements (CAPS) in South Africa, researchers focused on teachers' stages of concern during reform implementation. The purpose of the study was to examine the stages of concerns of 81 physical science teachers in 62 schools in the South African Department of Basic Education (DBE). Many of the DBE's multiple attempts to reform classroom practices and improve teaching and learning in subjects such as physical science, have failed (Gudyanga & Jita, 2018).

Gudyanga and Jita (2018) reported that the implementation process of the Curriculum and Assessment Policy Statements (CAPS) in physical sciences had obstacles that would have resulted in the failure of the reform. Most of the teachers had self-concerns more than anything. The three components of the SoC profiles were level of education, years of teaching experience, and years teaching under the new CAPS. When the stages of concern were compared to the teachers' level of education, teachers were grouped by obtaining a certificate or diploma and a university degree. Results indicated that there was no significant difference in the stages of concern based upon the participants' level of education (Gudyanga & Jita, 2018).

Although there was no significant difference, results also implied that those participants in the more educated groups were less concerned with knowing more about the CAPS than those who were not more educated. The stages of concern when compared to the teachers' years of teaching experience were examined using a one-way between-groups multivariate analysis of variance MANOVA test. The participants were divided into five groups according to the number of years they had been teaching up to February 2016: (1) more than 20 years; (2) 16-20 years; (3) 11-15 years; (4) 5-10 years; (5) under 5 years (Gudyanga & Jita, 2018).

The results indicated no significant difference among all four groups (Gudyanga & Jita, 2018). Participants with more than 20 years of teaching experience scored the least at the consequence stage of concern, suggesting that the impact CAPS had on learners was not a priority. Compared with the number of years teaching under CAPS, a one-way MANOVA was conducted. Participants were divided into four groups according to the number of years they had been teaching under CAPS as of December 2015 (Group 1: 4 years; Group 2: 3 years; Group 3: 2 years; Group 4: 1 year). Results implied that there was no significant variation according to the number of years of teaching under CAPS (Gudyanga & Jita, 2018).

The SoC profiles of those teachers who were in their fifth year of CAPS implementation did not vary significantly from the profiles of those teachers who were in their first year of CAPS implementation. The study suggested that the concerns profile may assist policymakers in developing adequate intervention programs aimed at easing teachers' implementation of new instructional practices and reforms (Gudyanga & Jita, 2018).

Using a mixed methods design, Haag and Megowan (2015) surveyed middle and high school science teachers from across the United States to examine their perceptions of readiness and motivation to implement the three-dimensional model. The researchers envisioned to determine characteristics of teachers who felt well prepared.

High school science teachers reported a higher degree of motivation to use science and engineering practices, felt more prepared to implement the practices, and enacted modeling instruction at higher rates than middle school teachers. Their increased motivation was credited to science teachers in grades 9-12 attending more days of training in modeling than science teachers of seventh and eighth graders (Haag & Megowan, 2015).

In a systematic review and critique of *Teaching Engineering Practices,* Cunningham and Carlsen (2014) suggested the necessity for teachers to participate in professional development that allowed them to engage in the practices that modeled pedagogies that support the practices. They suggested that teachers engage in practice during professional development that provides experiences as learners and teachers, and aids in the development of teachers' understanding of the fundamentals of engineering and the interconnections between engineering and science. The researchers also urged that professional learning be designed in ways that allow teachers to understand science and engineering as a social practice (Cunningham & Carlsen, 2014).

Limitations on Prior Research

Existing literature on science teachers' concerns and empirical studies on the implementation of science and engineering practices and the 5E instructional model, especially at the secondary level, were extremely limited in number and scope. It was anticipated that research on the implementation of the Next Generation Science Standards (NGSS), Georgia Standards of Excellence for Science (SGSE), science and engineering practices, and their impact on teachers, leaders, and student performance could be conducted and reported during the first years of implementation. Although the body of research on the topic is growing, very few studies about the standards, implementation processes, and its impact on student achievement have been conducted.

Summary

As science education has taken numerous turns in the nation, the need to improve and increase student achievement in science is still present. The launching of Sputnik was a reminder to the United States of the lack of preparation students had for a technical workforce. Since as early as the 1950's, efforts to improve student achievement in science education have been a continuous process. Educational reforms have acknowledged there is a variance in student learning abilities that must be addressed in order to see achievement of any kind. Multiple educational programs were developed in an attempt to improve science education in the United States.

In recent years, the NRC worked to establish a new vision for science education. With the publication of the Framework (2012), the NRC provided a research-based foundation to the revision of science standards. This revision led to NGSS which was developed from NRC's (2012) Framework. The three-dimensional model incorporated in the NGSS was to transform the focus of science education and employ science and engineering practices, cross cutting concepts, and disciplinary core ideas with scientific practice.

The 5E model has evolved over time to best serve its purpose in the classroom as a teaching model that is more activity-based to better help students acquire science concepts (Duran, 2003). Research showed the 5E model was effective in providing a permanent conceptual change in traditionally designed instruction, and the concept formation method of teaching using the 5E model was more effective as compared to traditional methods (Jack, 2017).

Individual beliefs tend to influence teachers' actions, which will affect their classroom instruction (Williams & Burden, 1997). As previously discussed, teachers' perceptions are most critical in educational research when seeking change in pedagogical practices. Although individuals do not have internal access to understanding their own behaviors, studying their perceptions gives voice to the individual. A person comes to "know" or better understand his/her own attitudes and behaviors by observing self-behavior and the situations in which those behaviors occur (Jhangiani & Tarry, 2014).

Table 1

Concept Analysis Chart: Personalized Learning

Study	Purpose	Participants	Design/Analysis	Outcome
DeMink-Carthew, Olofson, Leopros, Netcon, & Hennessey, (2017)	Investigated the goal-setting approaches of middle grade teachers during the first year of their implementation of a statewide, personalized learning initiative	11 middle grades teachers	Qualitative study/ The researchers analyzed the key features of each approach and then analyzed them using three key elements of personalized learning	Study found five dominant trends in teachers' approaches to goal setting

Easley (2017)	Investigated how personalized learning offered school librarians a way to maximize learner achievement by meeting students where they are	N/A	Literature Review	Effective school library programs can propel personalized learning environments in schools. Programs that support choice and voice, and just-in-time instruction promote learner agency and empower not only students but teachers as well.
Bernacki & Walkington (2018)	Examined if personalizing math units would improve student performance and report greater situational interest in units than students solving standard problems	150 ninth Grade Algebra I students in multiple classes; taught by two different teachers; Students attended a suburban/rural Northeastern school that was 96% Caucasian with 21% of students eligible for free/reduced lunch	Quantitative study/ Preliminary analysis and Main Analysis	High school students reported greater triggered situational interest in experimental units

Table 2

Concept Analysis Chart: 5E Instructional Model

Study	Purpose	Participants	Design/Analysis	Outcome
Shah, Muhammad, Abubaka, Khalid, & Uzma, 2019	Investigated the concept of magnetic hysteresis curves in physics, the effects of the 5E Model on students' understanding of concepts related to magnetic hysteresis curves	120 students from two higher secondary schools of the district of Mardan in India	Comparison analysis of the traditional method of teaching through the 5E Model and student's conception and understanding of magnetic hysteresis curves in physics	Students had an alternative conception on the concepts related to magnetic hysteresis curves that was an improvement to their previous conceptions
Hu, Gao, & Liu (2017)	Investigated the effects of 5E instructional model on the teaching processes of novice teachers	40 novice chemistry teachers working in different cities in China. The 40 teachers from different levels of school in China	Qualitative study/ Case study; collating the 40 novice teachers' scores for the different phases for the three kinds of instructional design, to determine whether there was any improvement in the teachers' instructional design process based on the model	The model can produce a positive impact on the development and improvement of novice teachers in their efforts at instructional design. The novice teachers improved their instructional design processes after being trained in the model. Improvements were different for each teacher.
Bybee (2014)	To design an instructional sequence that would help	N/A	Literature Review	Model has become widely used outside of

	teachers approach instruction in a meaningful way and enhance student learning.			the science curriculum.
Toman, Akdeniz, Cimer, Gurbuz (2013)	To prepare effective worksheets about ethanol fermentation, according to the 5E model based on the constructivist theory and identify the effects of the use of worksheets on learning in education environment	4 "expert" teachers from Bayburt University Science Education department and 28 students in their second year at Bayburt University	Qualitative study/ collected opinions of the four "expert" teachers and gave a pre and post assessment to the 28 students	The rate of student success increased after the worksheets. The worksheets developed based on constructivist approach enabled the students to actively participate during the learning process, help them to learn the subject better, and increase student success
Turgut & Gurbuz (2011)	To compare the effectiveness of the 5E model and traditional instruction on eighth grade students' understanding of heat and temperature concepts	37 eighth grade students. Participants were in two different classes and taught by the same teacher in the school year.	Descriptive study	The Heat and Temperature Concept Success Test indicated that the 5E model was more successful on remediation of misconceptions

Table 3

Concept Analysis Chart: Teacher's Perceptions of Educational Reform

Study	Purpose	Participants	Design/Analysis	Outcome
Laho, (2019)	Examined the impact of using a Learning Management System for school-home communications	83 teachers employed by the school system. Parents of students currently enrolled in a public school system in Michigan	Quantitative Study. A constant comparative method was used to analyze the open-ended responses for recurring patterns and themes	Results demonstrated that the LMS provided value as a one-stop location for resources and information.
Finster & Milanowski, (2018)	Examined teacher perceptions of Performance Evaluation Systems (PES)	12,292 educators across 515 schools in a large Midwestern United States school district	Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) to identify hidden factors of teacher perceptions of evaluation and to examine the relationships between the multiple hidden factors	In the establishment of new practices, teachers' perceptions of the quality of various reform efforts are critical for making implementation work effectively
Fitzgerald (2019)	To identify barriers inhibiting inquiry-based science teaching and potential solutions	34 positively inclined early-adopter teachers in relation to their implementation of inquiry-based pedagogies	Qualitative study/ manual analysis method and comparative and confirmatory analysis	Teachers were not even quite sure what inquiry-based learning actually meant. As found in other studies, just noting that inquiry must be undertaken in

	the curriculum documentation certainly does not lead to inquiry implementation in the classroom

CHAPTER III: METHODOLOGY

Throughout the years of science education, instructional practices have changed and been reevaluated. The "how" to teach science has not been clearly defined, but as previously discussed, various suggestions have been made. The effectiveness of student learning through the different instructional practices is based on the teacher perceptions of implementation (Organization for Economic Co-Operation and Development, 2009). Science teachers in Georgia began implementing the Georgia Standards of Excellence for Science during the 2017- 2018 school year. During the same school year, in the Excellence School District, science teachers were required to shift from their traditional instructional practice to implementation of the 5E Instructional Model.

The purpose of this study was to examine the perceptions of middle and high school science teachers in regard to the implementation of the 5E Instructional Model. This chapter is a representation of the research methods and procedures used to conduct the study. Sections include the research design, role of the researcher, setting, participants, instrumentation, data collection, validity, data analysis, and the summary.

Research Design

To conduct this study, the researcher used a qualitative descriptive study approach. The qualitative approach was the best fit for this study because it allowed the researcher to get an in-depth view of the 5E Instructional Model implementation and impact using the experiences of middle and high school science teachers. Quantitative methods would not have been sufficient to answer the research questions in this case because statistical significance would not provide any description or insight into how or why any resulting relationships existed (Creswell & Poth, 2018). The qualitative approach allowed the researcher to capture teachers' experiences with open-ended inquiry, which included strategies aimed at revealing underlying emotions and motivations (Creswell, 2006).

To answer the research questions, the researcher used qualitative data to reveal the perceptions and thoughts of the science teachers. The interview questions were designed from an instrument used in a previous research study by Sizemore (2018). The researcher contacted Sizemore to request permission to use the Interview Protocol Instrument and alter any questions to fit the needs of the study. Sizemore gave the researcher permission to use the instrument and asked that the researcher share their findings with her. Using the instrument as a guide, teachers in this study explained their perceptions of learning and teaching science through the implementation of the 5E Instructional Model.

The qualitative data were organized into a spreadsheet based on categories and emerging themes. Findings were analyzed using thematic techniques to better understand the research findings (Sutton & Austin, 2015). These techniques included assigning information to categories based on identified codes, using those codes to determine relationships among and between the codes identified, and grouping these related codes into themes for comparison and analysis (Johnson & Christensen, 2014; Miles & Huberman, 1994). It was decided that qualitative data was needed to further explain and interpret the findings.

Role of the Researcher

The researcher currently works for the Excellence School District as a science teacher. The researcher initially desired to complete the study in their former school district because there were similar dynamics to the implementation of the 5E Instructional Model. Due to the researcher not being able to obtain permission from the former school district to conduct the study, the researcher began to obtain information about the implementation process in the Excellence School District. The researcher learned of the similar dynamics for implementation and obtained permission to conduct the study. In the Excellence School District, fifty-three middle and high school science teachers were invited to participate in the study. The researcher had completed previous curriculum work with 12 of the middle and high school teachers who were invited to participate in the study; some were participants in the study. The researcher was used as an instrument in the semi-structured or qualitative interviews because unique researcher characteristics have the potential to influence the collection of empirical materials (Pezalla, Pettigrew, & Miller-Day, 2015).

Setting

The population for this study included all 53 middle and high school science teachers in Excellence School District who were invited to participate in the study. The Excellence School District is located in rural northeast Georgia. The school district has a total of 22 schools, with approximately 14,000 students, and 1100 teachers. A majority of the students in this district are students from low-income families and are from various ethnicities and races. Students fall under various academic backgrounds including but not limited to Advance Placement, English Language Learners, Gifted Education, and Special Education to name a few.

Participants

The population for this study included all 53 middle and high school science teachers in Excellence School District who were invited to participate in the study. Among the 53 science teachers who were invited to participate, 11 responded, and only 8 participated. The eight teachers selected to participate in the study represented diverse ethnic and racial, and educational backgrounds. Demographic data indicated that 75% of the participants were female and 25% were males, with 50% being White or Caucasian, 37.50% Black or African American, and 12.50% of another race. There were only two male participants, one African American and one Caucasian. There were six female participants of whom three were African American, two Caucasian, and one other race. The participants' teaching experience ranged from one to seventeen years of service. The teachers were teaching courses aligned to the Georgia Standards of Excellence for Science in 2018-2019. The study included participants from 2 out of 3 of the school district's high schools and 2 out of 4 of the school district's middle schools. To reduce barriers to science education for the students in the district, teachers needed to be able to implement lessons intended to reach all students.

The middle and high school science teachers were all required to be trained on implementing the 5E instructional model through a train the trainers' model, where the redelivery was completed by their assigned representative science teachers in 2017-2018. Trainers completed five total trainings before being required to train other teachers. Teachers were required to implement the new instructional model with little time to be trained. In 2018-2019, the participants had their first full year of teaching using the 5E model, considering that the first initiative to implement the practice was the 2017-2018 school year started. The total amount of trainings teachers received was not known by the researcher.

In selecting participants, the researcher utilized sampling techniques that were consistent with qualitative methods (Gentles, Charles, Ploeg, & McKibbon, 2015). A purposive sample of eight middle and high school science teachers was used in this study (Gay, Mills, & b, 2012; Creswell, 2007; Patton, 2002). Some of the middle and high school science teachers taught at the same school and some at different school locations. Most of the middle and high school science teachers had experience in collaborating through shared planning periods. Some of the middle and high school science teachers planned collaboratively and some individually. The study was conducted in the same school district whose middle and high school science teachers were implementing the same instructional model.

The participants in this research study were limited to middle and high school science teachers who taught Georgia Standards of Excellence for Science-based courses in two middle schools and two high schools within the Excellence School District. Participation from science teachers was expected to be high, because the topic was relevant to the daily work of middle and high school science teachers, and the potential findings could improve the implementation process. However, the response rate from potential participants was extremely low.

Instrumentation

To appropriately use the purposive sampling method, the researcher collected demographics data from all middle and high school science teachers in the selected schools. The demographic information questionnaire included the participant's number of years teaching experience, number of years teaching using the 5E model, grade level and science content taught, and number of professional development events attended for the 5E Instructional Model, provided by the district or outside entities. Demographic information was used to select study participants based upon their varying teaching experiences and levels of professional development with the 5E model.

Participants were asked to identify their educational level, such as undergraduate degree and graduate degree, if any. Participants were also asked to identify the field in which the degree was obtained. After identifying their education level, participants were asked to identify their years of teaching experience. The researcher expected a variety of responses ranging from 0 to 30 years. The demographic information also asked the number of years teaching using the 5E Instructional Model and the science content being taught, in order for the researcher to understand the perceptions of teachers and their actual experience from using the instructional practice. Lastly, the demographic information asked about the number of professional development events attended by the participants for the use of the 5E Instructional Model.

To get a more in-depth understanding of the experiences of middle and high school science teachers in implementing the 5E Instructional Model in science classrooms, the researcher utilized semi-structured interviews to collect data from middle and high school science teachers on their perceptions of the implementation of the 5E Instructional Model. Instrumentation for the study included the Interview Protocol (see Appendix B) and Demographic Survey (see Appendix C) which was administered prior to the interview.

The interview protocol consisted of six main questions. Each of the main questions had 1-6 sub questions that the researcher asked participants as well. The researcher maintained the order of the questions as provided on the hard copy for participants and was intentional about the guiding questions asked, with hopes to open up the interview for further questioning and to understand the phenomena of experiences middle and high school teachers described.

The researcher cross referenced each of the guiding questions of the interview protocol form to the research questions developed for the study (Table 4).

Table 4

Cross Reference Table

Research Question(s)	Interview Protocol Guiding Questions
(1): To what extent do middle and high school science teachers perceive that the use of the 5E Instructional Model impacts classroom instruction?	Question 2: What experiences have you had with the 5E Instructional Model? Question 4: Describe your typical classroom day, where the 5E Instructional Model principles are used. Question 5: How are the guiding principles of the 5E Instructional Model utilized in your school?
(2): To what extent do middle and high school science teachers understand the purpose of learning and teaching of science through the implementation of the 5E instructional model?	Question 1: What do you know about the 5E Instructional Model? Question 3: Do the teachers you work with use the principles of the 5E Instructional Model? Question 6: When planning lessons how do you plan for personalized learning for students in the classroom?
(3): To what extent do the perceptions of middle and high school science teachers differ in regards to their preparation for implementation of the 5E instructional model?	Analysis of middle and high school science teachers' perspectives

To answer the first research question, “To what extent do middle and high school science teachers perceive that the use of the 5E Instructional Model impacts classroom instruction?”, questions 2, 4, and 5 of the interview protocol were used. To answer the second research question, “To what extent do select middle and high school science teachers understand the purpose of learning and teaching of science through the implementation of the 5E instructional model?”, questions 1, 3, and 6 of the interview protocol were used. To answer the third research question, the researcher analyzed the responses of middle and high school science teachers to identify in what ways perspectives on implementation of the 5E model were similar or different.

Data Collection

The researcher followed the Excellence School Districts’ Research Request Protocols to gain permission to conduct the study in their school district. The researcher submitted a Research Request Form to the Department of Research for the Excellence School District and emailed the Director of Research with information about the topic and a copy of the letter of cooperation, as well as a copy of the informed consent for school principals and science teachers. The researcher provided a copy of the interview protocol and explained the intent of the study.

Once permission was granted and consent was obtained from the Director of Research, the researcher began following the procedures for approval from the Institutional Review Board (IRB) of Columbus State University.

Due to the process the Excellence School District uses to grant permission to engage in research, the researcher did not have to email school principals because this was included in the Request to Research Process by the school district. Once IRB approval was obtained, the researcher used district emails to contact the science teachers of all middle and high schools in the district from the researcher's Columbus State student email. In the email, the researcher provided information about the purpose of the study and attached a copy of the interview protocol. The science teachers who chose to participate were also requested to digitally sign the letter of consent to identify that they agreed to participate in the study. Teachers that did not respond were sent a duplicate email three days later. If there was still no response, the teacher was contacted by telephone as a final attempt to include the school's teachers in the study.

Interview participants received an email with the options to schedule the interview on a mutually agreed upon day and time. Prior to starting the interviews, the researcher presented the participants with the informed consent and the opportunity to accept or decline participation through Survey Monkey (Cohen & Crabtree, 2006). The informed consent included the explanation and purpose of the study, a description of how data would be collected and used, the minimal risk to participating in the study, the goal of the study, and the procedures for withdrawal from the study. The researcher reminded participants of each component of the informed consent form. Special emphasis was placed on confidentiality and procedures for withdrawal. Participants were then allowed to agree or disagree to participate in the study. If a participant chose to continue in the study, the researcher briefly discussed the 5E Instructional Model Framework with the participant. The researcher discussed the structure of the 5E model and what previous research has suggested from the implementation of the 5E model in science instruction. For participants who chose not to continue in the study, demographic information was not collected and discontinuation was recorded. There were no gifts, tokens, or rewards provided to the participants for their participation. The researcher ensured that participants understood that they could withdraw from the study at any time with no pressure.

Each participant engaged individually in a 45- to 50-minute semi-structured, open-ended interview conducted virtually via Google Meet and digitally recorded through the Temi transcription software. The recorded data from the virtual Google Meet interviews were transcribed through Temi. The researcher audio recorded the interviews using a digital electronic device. Participants used their first name only and were reminded of the importance of confidentiality. A copy of the researcher's narrative for individual participants was emailed to participants for member checking purposes. The researcher's narrative did not include any identifiable information. The researcher used a spreadsheet that included content analysis and thematic analysis for sorting, participants' interview numbers to maintain confidentiality, and trends identified between middle and high school science teachers. The spreadsheet included demographic information of participants, specific quotes from participants, and responses to open ended questions. The purpose of the spreadsheet was to organize data for analysis and identify themes to further understand the topic.

Validity

To ensure trustworthiness of the data collected during the semi-structured interviews, member checking and note taking were utilized. Each data collection instrument was used to triangulate data, understanding that the recorders may not have captured all of a participant's response. According to Lincoln and Guba (1985), member checking is the most essential technique to establish trustworthiness. During the interviews, the researcher used paraphrasing, summarization for clarification, and probing techniques to clarify participant responses, as appropriate.

Data Analysis

In this study, the following research questions were addressed.

(RQ1): To what extent do middle and high school science teachers perceive that the use of the 5E Instructional Model impacts classroom instruction?

(RQ2): To what extent do middle and high school science teachers understand the purpose of learning and teaching of science through the implementation of the 5E Instructional Model?

(RQ3): To what extent do the perceptions of middle and high school science teachers differ in regards to their perceptions of implementation of the 5E Instructional Model?

The recorded data from the virtual Google Meet interviews were transcribed through Temi. Data were analyzed by reading through the text data, dividing the text into segments of information, labeling the information with codes, reducing overlap and redundancy of codes, and collapsing the codes into themes (Creswell, 2008).
Each question and sub question was labeled with the participant interview number to aid the researcher in describing the data. Participants were assigned interview numbers to maintain their confidentiality on spreadsheets and other data collection documents utilized.

The researcher sorted the data collected using content and thematic analysis. The researcher used the sorted information to further analyze each identifier to ensure all responses for each question and theme were organized together. The researcher looked for categories, common categories, and finally themes in the data and sorted the responses into more specific categories when necessary. The sorted data were used to draw conclusions to answer the research questions in this study as well as compare to findings from previous studies.

Summary

To answer the research questions, the researcher used a qualitative study to determine middle and high school science teachers' perceptions of the impact of implementing the 5E Instructional Model. The target population was composed of middle and high school science teachers in an Excellence School District. Once approved by the Superintendent and Institutional Review Board at the university, the researcher met with teachers to introduce the study, obtain consent for those who wished to participate and collect demographics information. Using purposive sampling, the researcher identified participants for the semi-structured interviews. The semi-structured interviews were conducted at a location, time, and date chosen by the participant to maximize participation.

Using interview protocol questions, data from the middle and high school science teachers were analyzed and compared to determine emerging themes and draw conclusions. Audio recordings were transcribed by the researcher and a copy of the researcher's narrative was e-mailed to participants for member checking. These data were organized into tables and graphs and synthesized to determine an overall impact of the 5E Instructional Model on the instructional practices of middle and high school science teachers.

Table 5

Research Confirmation

Research Question	Instrument/Analysis	How will strategy answer research questions?
1. Perceptions of the 5E Instructional Model impacting classroom instruction	Individual semi-structured interviews/coding and narrative data	Narrative data and themes from the individual semi-structured interviews explained and expounded on the qualitative results.
2. Understanding the purpose of learning and teaching of science through the 5E instructional model	Individual semi-structured interviews/coding and narrative data	Narrative data and themes from the individual semi-structured interviews explained and expounded on the qualitative results.
3. Differences in perceptions in regards to preparation for implementation of the 5E Model	Individual semi-structured interviews/coding and narrative data	Narrative data and themes from the individual semi-structured interviews explained and expounded on the qualitative results.

Table 6

Semi- Structured Interview Protocol Item Analysis

Item	Research	Protocol Question	Research Question
1. What do you know about the 5E Instructional Model?	Bybee et. al., 2006	1	2,3
2. What experiences have you had with 5E Instructional Model?	Haag & Megowan, 2015;	2	1,3
3. Do the teachers you work with use the principles of the 5E Instructional Model?	Duran & Duran, 2004	3	2,3
4. Describe your typical classroom day, where the 5E Instructional Model principles are used.	Duran& Duran, 2004;	4	1,3

	McHenry & Borger, 2013; Lawson & Karplus, 2002		
5. How are the guiding principles of 5E Instructional Model utilized in your school?	Duran& Duran, 2004; McHenry & Borger, 2013; Lawson & Karplus, 2002	5	1,3
6. When planning lessons how do you plan for personalized learning for students in the classroom?	Bybee et. al., 2006; Duran& Duran, 2004; McHenry & Borger, 2013; Lawson & Karplus, 2002	6	2,3

CHAPTER IV: RESULTS

The purpose of this study was to examine the perceptions of middle and high school science teachers in regard to the implementation of the 5E Instructional Model. In the state of Georgia, science education leaders saw a need to change the way science was taught to students based upon reform that took place at the national level. The restructuring of science education in the state of Georgia included not only new standards, but also practices that were expected to be implemented by Georgia science teachers. The 5E Instructional Model was one of the few that was expected to be included in this implementation process. In 2016, the state of Georgia began its work to develop the Georgia Standards of Excellence for Science (GSE) which were intended to be implemented across the state in the 2017-2018 school year (Georgia Department of Education, 2020).

To explore the implementation of the 5E Instructional Model in middle and high school science instruction, the researcher engaged in a qualitative descriptive study to capture teachers' perceptions of the 5E Instructional Model and its impact during their instruction. This crossing of teachers' perceptions, the implementation process and its impact on teaching and learning was the focus in this study. The autonomy of implementation methods afforded to school districts in the state of Georgia resulted in differences among districts and even schools within the same district. Utilizing a single school district created a more homogeneous environment allowing the researcher to provide rich descriptions of how teachers perceived the implementation of the 5E Instructional Model. The study included a purposive sample of eight middle and high school science teachers selected based on their training and implementation of the 5E

Instructional Model during the 2017-2018 school year. Data resulting from the demographics survey and semi-structured interviews, were coded using indirect coding. The resulting themes are presented in this chapter. The following major elements comprise this chapter: introduction, participants, findings for each research question, and the summary.

The study was guided by three main research questions:

RQ1: To what extent do middle and high school science teachers perceive that the use of the 5E Instructional Model impacts their classroom instruction?

RQ2: To what extent do middle and high school science teachers understand the purpose of learning and teaching science through the implementation of the 5E instructional model?

RQ3: To what extent do the perceptions of middle and high school science teachers differ in regards to their preparation for implementation of the 5E instructional model?

Participants

Science teachers from the middle and high schools selected for the study were recruited using an email invitation. Email invitations were sent to a total of 53 middle and high school science teachers; however, only 11 responded and 8 were included in the study. Three respondents were not able to participate because although they had enough years of teaching experience, they did not work in the district when training took place and were not teaching using the 5E Instructional Model. Teachers were emailed the informed consent and were able to opt in or out of participation of the study. Those who opted in were directed to complete the demographics survey, and those who opted out were directed to a “Thank You” page and ensured that their information would be discarded appropriately.

To protect the confidentiality of the participants, each participant was assigned a pseudonym. Participant pseudonyms and demographics appear in Table 5. The criteria for a participant to be included in the study were that they had to be working in the Excellence School District in the 2017- 2018 and 2018- 2019 school years and be a science teacher who received professional learning and implemented the 5E Model during the indicated school years. The science teachers included in the study shared common implementation experiences and were provided time during the school day to attend one required professional learning experience on implementing the 5E Model.

Table 7

Participant Demographics

Pseudonym	Gender	Ethnicity	Years of teaching experience	Years of teaching using 5E Model	Grade level taught
Adrianne	Female	White/ Caucasian	0-3 years	0-3 years	High School
Antwon	Male	Black/African American	4-6 years	4-6 years	Middle School
Becca	Female	Of Other Race	4-6 years	0-3 years	High School
Bethany	Female	White/ Caucasian	14-17 years	0-3 years	High School
Maurice	Male	White/ Caucasian	4-6 years	0-3 years	Middle School
Maryann	Female	White/ Caucasian	4-6 years	0-3 years	High School
Deidre	Female	Black/African American	14-17 years	14-17 years	High School
Dianne	Female	Black/African American	7-10 years	0-3 years	High School

Participants included six females and two males. All of the eight participants taught science, two had taught for 14-17 years, one had taught for 7-10 years, four had taught for 4-6 years, and one had taught for 0-3 years. All participants who were selected met the criteria and were capable of sharing their perceptions of the training and implementation of the 5E Instructional Model. A majority of the science teachers shared the same experiences for training, but some had differences in the implementation process.

Participant profiles

Adrianne

Adrianne was one of the high school science participants, who taught in the school district for three years. Adrianne holds a Bachelor's degree in a non-educational field and was in pursuit of her master's degree in special education. Adrianne taught in a collaborative teaching classroom for inclusion students and on level students.

Antwon

Antwon taught for four years in the school district and holds a Bachelor's degree in education. He is certified in middle and high school science and serves on the leadership team for his school. He enjoys teaching middle school and the opportunity of teaching select high school courses at the middle grades level.

Becca

Becca had taught in the school district for four years. She moved from up north to begin her career in education. Becca was a young vibrant high school science teacher who believed that change was not always a bad thing. After the completion of an educator bridge program to recruit and train individuals to be certified teachers for public school teaching, Becca obtained her master's degree in education.

Bethany

Bethany was a vibrant veteran teacher. She holds a master's degree in education and was Gifted, Science and Special Education certified. Bethany had taught for over 16 years and had a lot of experience with curriculum writing. Bethany had taught various science content and had worked with multiple "special groups" selected by instructional leaders in the district to develop instructional resources for science teachers. Bethany had seen various changes take place in science education.

Maurice

Maurice was a teacher with over four years of teaching experience between two school districts. Maurice loves a challenge and was always willing to try new strategies to help increase student learning.

Maryann

Maryann was a mid-age high school science teacher who speaks multiple languages and had travelled the world through previous job experiences. Maryann's family moved south where she completed her master's degree through an educational bridge program developed to recruit and train prospective teachers from all over.

Deidre

Deidre had taught for over 16 years and taught in the district for over nine of those years. She also moved from the north where she began her teaching experience. Deidre worked as a behavior interventionist and teacher before moving to the south. Deidre realized how the educational systems in the north and south were not so much different in terms of educational reform. She believed that all of it was to increase student learning and offset behavioral issues. Deidre had a passion like none other for teaching.

Dianne

Dianne was a young vibrant teacher who had taught for over seven years. Dianne taught in a smaller district before coming to teach in the district. She had a wealth of knowledge and experience that she was willing to share with the world. Dianne was also a student in the district and had a great sense of pride to give back. Dianne described multiple events during classroom instruction where she strived to provide practical real world experiences to her students.

Findings

The purpose of this study was to examine the perceptions of middle and high school teachers in regard to the implementation of the 5E Instructional Model. Because a gap in research existed on how teachers perceived the implementation of the 5E Instructional Model impacted their science instruction, the study was conducted to explore this phenomenon. The study was guided by three research questions aimed at gathering teachers' perceptions of the impact, purpose and preparation of the 5E Model. Eight participants were included in the study. Data were triangulated from the following sources: researcher's notes, member checking from participants, and semi-structured interviews.

The themes that were formed from the raw data were organized and reported by research questions in a manner deemed by the researcher to be most informative. Thematic analysis was used to organize the data and display in summary tables that included descriptions from each participant to organize findings. Given that the research was a qualitative descriptive study, descriptions were used as the main source of data. Each description used the participants' actual words to communicate the major themes and give voice to each participant's true perceptions (Gay, Mills, & Airasian, 2012; Creswell, 2013; Yin, 2013). Any references made by participants that indicated names of peers, school location, and lessons were removed and changed with the use of pseudonyms.

The following themes emerged from the three research questions. Two themes emerged from research question one, which examined teachers' perceptions of the impact the implementation of the 5E Model had on science instruction: provides structure to the teaching and learning process and requires more time to develop and implement lessons. Two themes emerged from research question two, which examined the perceptions on the purpose of implementing the 5E Model: provides more student-centered instruction and provides more hands-on learning for students in science. Research question three served as a contrasting question to identify if the perceptions of middle and high school science teachers differed in their perceptions of the impact of the 5E Instructional Model on instruction.

Research Question 1: Impact of the 5E Model

RQ 1: To what extent do middle and high school science teachers perceive that the use of the 5E Instructional Model impacts their classroom instruction?

The researcher sought to gain middle and high school science teachers' perceptions of the use and impact of the 5E Instructional Model in science instruction. During interviews all participants were asked to share their perceptions on the use of the 5E Instructional Model as it related to their experience, a typical classroom day, it's utilization in their school setting, and its' impact on their classroom instruction. Interview questions 2, 4, and 5 served to provide information about the impact of the 5E Instructional Model in the science classroom. Interview question two asked participants what experiences they had with the 5E Instructional Model. Interview question four asked participants to describe a typical classroom day where the principles of the 5E model are used. Interview question five asked participants how the entire structure of the 5E Instructional Model was utilized in their school.

Participants described and shared the experiences they had with the 5E Instructional Model. A majority of the participants had some form of experiences with the 5E Model and described how they used it in a typical classroom day; however, they did not use it in its entirety due to time limitations. They also described the expectation for utilization in their school and how the 5E Model was utilized to plan lessons.

Use of the 5E model.

These participants all stated that they had training, but the consistent experience of usage of the 5E model was not present during their instruction. Of the eight participants, 37% stated that they had very little experience teaching using the 5E model and 63% stated that they had a great deal of experience teaching using the 5E model. One hundred percent of the participants reported that they do not use the 5E model to its full extent due to the time it takes to complete a full 5E model lesson. Many described how they would only use parts of the 5E model due to how extensive a lesson following the 5E model could be.

Adrianne had little experience using the 5E model. She stated, "I did it in grad school. One of our classes we had to write a lesson plan, like create our own lesson plan using the 5E Model, but I've never implemented one fully in my instruction until last year."

Maurice and Dianne also had little experience with the model, but a lot of knowledge from what was provided in the Excellence School District Curriculum Portal. They reported using only parts of the 5E model. Maurice said, "Well, the lessons that are put into our curriculum portals for middle school models lessons, but it may be like a three- or four-day lesson. So I use parts of the 5E model." Dianne felt as if time was not always on her side during instruction and stated, "I do parts of the model because of the time frame and based upon individual student needs."

Becca said "I was getting my master's degree and teaching. I learned through another teacher five years ago. I learned about it through her because I think she was one of the teachers that had to do like the five trainings to train others." She stated, "I used it a couple of times with my advanced students. We would do something fun as a lab for the Explore, but I did not like to dive so deep into what is required with the 5E model. Exit tickets are my Evaluate. Remediation would be like Elaborate."

Deidre used parts of the 5E model and stated "I use it as part of my openers and closings. I might open the class with the engage. I put a video on the board and ask students what are some questions they have. I write their questions down and we don't even try to answer them, just get the question. Everybody's heated and their brains are going, excited about what's to come."

Antwon stated "I have about four years of experience with it. I try to incorporate the 5E model in every lesson considering the great work that has been provided in the district's curriculum portal." However, he said that he often did not use the model in its entirety stating, "I use more of the engage and explore,"

Bethany said, "I have a lot of experience and was always involved in writing the curriculum for the portal which took a lot of work. When we started to do the 5E Model, that's when we had to come up with a phenomenon. The first year was awkward." She questioned calling their typical classroom day of using the 5E model an actual 5E lesson, because she felt it was in parts. She said, "My opener is kind of something to hook them, more like my Engage. In a typical day, I can only do parts of the model due to time. I usually use the Engage and Evaluate at most. My labs are what I consider to be the Explore."

The 5E model as a structure for teaching and learning.

All participants felt that the experience they have had with the 5E model has helped them provide a form of structure to their teaching and the learning process. One hundred percent of the science teachers voiced that they use the Engage which is like doing an opening session during a day's lesson. Fifty percent of the science teachers stated that labs were considered to be their Explore and 75% implemented the Explain. Seventy- five percent of the science teachers implemented the Evaluate, and only 13% of the teachers mentioned the Elaborate.

Antwon and Adrianne felt that the 5E model improved their planning skills. Antwon said, "I feel like it's made me into a better planner, like a better backwards design planner." He added, "It helped me with my organization and planning for lessons." He described how the 5E helped structure lessons by starting with the opener. "This is like the Engage for the 5E model, but I am always asking questions to make the connections needed for the lesson continuation. Sometimes the lessons provided in the portal are what I use for the Explore, and I use the Evaluate to assess what students knew at the Engage and what they know after going through the full lesson."

Adrianne stated, "There has not been one time I could actually do multiple "E's" in one day. The Engage is the most important thing; if the kids do not care about what they are learning, they may not learn. Students have videos that they watch to engage them and are responsible for making meaning for their learning when they get to the Explain. The Evaluate process is I cut them loose and see if they actually learned what I taught."

Bethany and Becca described how their classroom management skills improved through the use of the 5E model. Bethany said, "My classroom management is pretty good now because of it." Becca also talked about how she used parts of the 5E model to structure a couple of her lessons for advanced students. She stated, "We would do something fun as a lab for the Explore . . . Exit tickets are my Evaluate. It helps with engagement. And for me it keeps you on task. And then I think for this student, I think it's kind of like dual purpose. It's also sort of like building trust within the teaching."

Maurice described similar use of the 5E model to structure lessons by stating, "So the Engage would probably be early on like our opener. And then we would have a time to Explore and then Explain, and Evaluate would be when we have some version of exit ticket. I feel like I do use them to an extent, but sometimes they're probably not as defined as it should be in a typical day."

Maryann, Deidre, and Dianne all described how their typical day mostly consisted of using the Engage and Explain, and labs were more than likely used as their Explore.

Maryann stated, “I use the engage to get the lesson started. After students do that, then they'll go to like a lab station where they will explore. Students take the data and analyze it. I use assessments to evaluate them, but none of this can be completely done in one class period.” Deidre said, “I might open the class with the engage. So then, we go into the Explain and Explore part. I ask them to explain a little deeply to push students to be that analytical thinker. Then we evaluate which can be a self-evaluation or teacher evaluation. Most lessons last at most a week or two.” Dianne also said, “I show them a video first to get them thinking about and ask them some questions, have a mini discussion, maybe about five or 10 minutes and then break them up into groups. Then we explore and explain. Some lessons require more time which developed my wait time.”

District and school expectations.

Fifty percent of the science teachers stated that in their school building, they did not feel there was an explicit expectation or structure for the utilization of the 5E model. Antwon, Adrianne, Bethany, and Becca all stated in their own way that there was no expectation for utilization of the 5E model in their individual school buildings. Antwon stated, “There is not an explicit structure for the utilization of the 5E model at my school. I feel like when we're having conversations with our Instructional Coaches or with teachers, a lot of times we run into issues. I feel like we have to remind Instructional Leaders that we are planning in a framework with the 5E model that gives students more experience.” Adrianne also said, “I'll be honest. I don't know what our school expectation is if we just be real. My team collaborated and we didn't explicitly say we will do all 5E’s.” Bethany said, “I can’t say there is a structure. I think at our school, we are still very independent on how we can create lessons in our own format.” Becca’s response gave further explanation as to why there were some who felt there was a lack of expectation for the implementation of the 5E model. She stated, “The structure is non-existent. The only teachers who were talking about the 5E model in my school were older teachers. When we were required to use it after trainings, no one in my school building came to evaluate me on it. My Instructional Coaches did not assist me in the implementation of it. I feel like anytime we change leadership, which is pretty much every year, there's a new instructional model that we're using.”

Fifty percent of science teachers stated that although it was not explicitly stated, there was some form of expectation or structure for the utilization of the 5E model. Maurice, Maryann, Deidre, and Dianne, all described how they believed there was some form of expectation even if it was not directly stated. Maurice stated, “I think that we are to use the 5E Model. So I guess the expectation is because our model lessons that we have in our portals are set up in the 5E manner.” Becca said, “I would say that I assumed that because we were given training from the district that using the 5E model was an expectation. However, I've never been evaluated on it or even observed on it or commented on it or anything from my building level leaders or district.” Dianne also said, “The expectation is that the students are doing the work and not us doing the work. We use what the district has provided us and can add some of our own teacher made material.”

Research Question 2: Purpose of the 5E Model.

RQ 2: To what extent do middle and high school science teachers understand the purpose of learning and teaching science through the implementation of the 5E instructional model?

The researcher sought to gain middle and high school science teachers' perceptions of the use of the 5E Instructional Model in science instruction. During interviews all participants were asked to share their perceptions on the use of the 5E Instructional Model as it relates to their knowledge of the 5E model, the percentage of teachers in their building who use the 5E model, and their planning for personalized learning using the 5E model. Interview questions 1, 3, and 6 served to provide information about the purpose of teaching and learning through the 5E Instructional Model in the science classroom. The researcher determined from their notes of responses on interview questions four and five that a gap existed between teachers' understanding of the 5E model and the expectation of implementation process.

Knowledge of the 5E model.

Interview questions one and three both asked about the knowledge obtained about the 5E model by the participant science teachers. Science teachers described the knowledge they had about the 5E model and the percentage of science teachers in their school building who knew about the 5E model. One hundred percent of the teachers described how they had knowledge of the 5E model and were able to see the benefits of its use. They all had knowledge of the 5E model to some extent but could only identify parts of the model.

Adrianne stated, "I know of it, but I don't think that I'm an expert." She added, "So we were in the beginning stages of training for the use of 5E when I started here. I knew the Engage and Explain from lessons in college. Now I am knowledgeable. The model is supposed to improve your kids' learning outcomes."

Antwon said, “I know that I wasn't super familiar with the name, but I do know that I've been trained on it. I know that it is a way to help kids feel more of an authentic experience in the sciences.” Becca said, “It helps with engagement. The purpose for the teacher is to facilitate how students explore a topic and give time to really engage with the content. And for me, it keeps the teacher on task.” Dianne also stated, “I know it’s a model used for getting students to think. The 5E model actually allows the student metacognition to think about what they’re learning and to actually get it wrong and let them know that it's okay to get it wrong, but in getting it wrong, they figure it out.”

Maurice said, “I know what the 5E's are and I kind of get the idea behind it, I guess. I know there's Engage and Explore. . . I think the purpose is to break the content down to the different parts that will allow students to actually do science. It also makes the learning more hands on,”

Deidre had received training on the 5E model in another school district and was knowledgeable about the model. She said, “The public schools wanted science to become more activity-based, as they were saying for minority children that activity-based classrooms for science might be better for them because they thought that the children would be more engaged.”

All participants felt that the 5E model was a push to allow students to actually “do” science instead of merely learning facts. Most participants were able to voice how the Engage was what helped to get students interested in scientific topics and learning. Bethany said, “I believed the model was a tool used to help students look at things and analyze and not just remember facts. To make students become intrigued and interested and engaged.”

Personalized learning.

Interview question six asked participants how they plan for personalized learning for students in the classroom. Sixty-two percent of science teachers stated that they collaborated with other science teachers to personalize learning for students with and without the use of the 5E model. Thirty-eight percent of participants indicated that their planning began with assessment data which helped them understand how to best serve students.

Antwon described how the collaborative planning sessions are almost 45 minutes long and so everyone is in a fight to get things done. "Usually there is not ever enough time for everything we want to do. So it was like double or we have two days to plan. So it's gotten to a point where it's like 45 minutes planning session. Everybody comes in, let's get to work," said Antwon.

Adrianne expressed how the Engage phase is most important in their collaborative planning. "My collaborative team work to develop for the kids. Most of times me and my Collab Teachers would work to meet the need of every student," stated Adrianne. She added, "I plan based upon my assessment data."

Bethany also stated, "We looked at being more intentional about what we are including in lessons. We changed the structure of our units to meet the academic needs of all students." Bethany described how they are mostly in a crunch for time, but still work to meet the need of students to make learning more personalized in collaborative meetings.

Maurice said, "I plan based upon what me and my collaborative team comes up with from test data." Similarly, Deidre stated, "I use assessment data to help drive my planning process. I collaborate with my team to use evidence-based practices like the 5E to help meet the students' needs because I teach a diverse group."

Participants also described how they perceived that the 5E model sets the framework for students to actually be scientists. The participants perceived the purpose of the 5E model was to provide a student-centered teaching process and a more hands-on learning approach. Antwon described how the 5E model allowed students to be scientists: "So it sets the framework for them to actually be scientists and do the scientific method, analyze a problem and information on like why things happen or how to solve it. Exploring and experiencing science really makes like a real impact on the kids learning." Bethany said, "I believe the model was a tool used to help students look at things and analyze and not just remember facts. To make students become intrigued and interested and engaged. It's much more student-centered." Becca stated, "I think this is student-centered, I think it's kind of like dual purpose. It's also sort of like building trust within the teaching." Maurice explained, "I think the purpose is to break the content down to the different parts that will allow students to actually do science. It also makes the learning more hands on."

Research Question 3: Comparing Middle and High School Teachers' Perceptions

RQ 3: To what extent do the perceptions of middle and high school science teachers differ in regards to their preparation for implementation of the 5E instructional model?

Of the eight participants in the study, two were middle school science teachers and six were high school science teachers. One hundred percent of the middle school teachers had the same perceptions as the high school science teachers. Both middle and high school science teachers perceived that the 5E Instructional Model impacted their science instruction, but there was a time limitation that affected their use of the model. High school science teachers stated that their instructional time was about 55 minutes whereas middle school science teachers had the benefit of having 75 minutes of instructional time.

Maurice, a middle school teacher, stated, “It might take a few extra days teaching material using the 5E model and as we don't want to have to shorten a lesson because using the model develops real meaningful learning. To have fidelity in using the 5E model, I may extend certain parts of the model over three or four days because it requires a lot of time. Sometimes I only use parts of the model.” Antwon, the other middle school teacher, said, “I feel like when we're having conversations with our Instructional Coaches or with teachers, a lot of times we run into issues because of time.”

High school teachers also talked about the issue of time. Bethany said, “The teachers I work with use it. I think we had discussions about how the phenomenon can take too much time. So, I think at our school, we are still very independent on how we can create lessons in our own format.” Dianne stated, “We use what the district has provided us and can add some of our own teacher made material. However, the 5E Model needs more time for use within classroom instruction.”

Both middle and high school science teachers perceived to have minimal resources provided by the district, and support from individual building instructional leaders to continually implement the 5E model was not present. Antwon, a middle school teacher stated, “I feel like for us, we have to constantly remind our evaluators, our administrators and our instructional coaches, about how we plan with the 5E model in mind. The issue is that most are not familiar and can only provide minimal support." Becca, a high school science teacher stated, "When we were required to use the 5E Model after trainings, no one in my school building came to evaluate me on it. My instructional coaches did not assist me in the implementation of it."

Summary

The results were presented in Chapter IV. The results were linked to each research question to give voice to the perceptions of eight middle and high school science teachers on the impact of the 5E Instructional Model. A qualitative descriptive study was conducted with eight participants who had worked and received training on the 5E Model in the Excellence School District in the 2017- 2018 and 2018-2019 school years. A semi-structured interview protocol was developed to guide the interview process and answer the three research questions. The researcher conducted face-to-face Google Meet interviews with participants and documented the results.

CHAPTER V: DISCUSSION

Summary of the Study

The launching of Sputnik I in 1957 was a reminder to the United States as to how far behind they were in science education (Wissher, Concannon, & Barrow, 2011). The United States feared that graduates lacked mathematical and scientific skills needed for the country to improve with technological advances. Sputnik brought about immediate changes to science education (Nelson, 1997). After Sputnik, several reformations began to take initiative in the United States all with efforts to improve science education. Studies began to surface about the underachievement in the United States during the Reagan Administration time. In 1983, the National Commission on Excellence in Education produced *A Nation at Risk: The Imperative for Education* which opposed several of Reagan's policies in education. In response to "A Nation at Risk," The National Research Council, the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS), and Achieve worked together to rewrite science standards and curriculum in the United States (NRC, 2012). These organizations worked together as partners to develop the Next Generation Science Standards (NGSS).

In the state of Georgia, science education leaders began to see the need for a change in the way science needed to be taught to students after major shifts that took place in science education on the national level. In 2016, the state of Georgia developed the Georgia Standards of Excellence for Science (GSE). This work entailed a restructuring of the Georgia Performance Standards into the GSE to provide more of a practical approach to science learning. The new GSE Science Standards included 3-D

Model Learning, Crosscutting Cutting Concepts, Phenomena, and the use of the 5E Instructional Model (National Research Council, 2013).

Science teachers in the state of Georgia were expected to implement these instructional strategies in the 2017- 2018 school year. Previous research indicates there are challenges to implementing reform in science education. Considering the timing of events that has caused a shift in the way science is taught, the researcher wanted to examine the impact of the 5E Instructional Model on science instruction in a Northeast Georgia School District. Training and implementation of the 5E Model took place after the start of the 2017-2018 school year, which prompted the researcher to examine the perceptions of middle and high school science teachers in regard to the implementation of the 5E Instructional Model. The researcher used purposive sampling to interview middle and high school science teachers in a qualitative descriptive study based on the teachers' perceptions of the 5E Instructional Model and its impact during their instruction.

The researcher conducted a qualitative descriptive study that included eight middle and high school science teachers. The researcher used purposive sampling to select study participants and demographic surveys and semi-structured interviews to collect data from science teachers. The researcher obtained permission to conduct the study from Excellence School District Research Department, following all guidelines to obtain approval. The researcher emailed invitations to a total of 53 middle and high school science teachers, however only 11 responded and 8 were included in the study. Three respondents were not able to participate in the study because although they had enough years of teaching experience, they did not have experience with using the 5E Instructional Model. After participants completed the Informed Consent, semi structured interviews were scheduled and recorded on an electronic device. Temi was used to translate the interviews and the transcriptions were uploaded into NVIVO 12 Pro. The data were presented in Chapter IV.

Analysis of the Findings

Data analysis consisted of the triangulation of multiple data sources that included data from the semi-structured interviews, the researcher's notes taken during interviews, and the member checks. Data were collected from eight high school teachers who met the criteria of having taught an academic subject at the chosen school during the 2017-2018 and 2018-2019 school year. Each teacher in the sample also met the requirement of having participated in district-wide training for the 5E model. The large amounts of data resulting from participant demographic surveys and semi-structured interviews were reduced to the emerging themes for this study through data analysis (Creswell, 2007; Merriam & Tisdell, 2016; Patton, 2002). The analysis and discussion of the four themes presented below, represents participants' perceptions of the implementation of the 5E Instructional Model. The information confirmed that teachers perceived the 5E Instructional Model to have impact on science instruction. Therefore, the participants were able to provide authentic feedback on the impact the 5E Instructional Model had on their science instruction.

From the semi-structured interviews and researcher's notes, the researcher noticed that many of the science teachers voiced that they were correlating the 5E model to their daily instructional framework, expecting it to be a day's lesson. After learning that the 5E model had more depth to it, the science teachers were using it in parts where they felt it most convenient. The perceptions of most participants were that they were implementing the 5E Model to some degree even if they never mentioned what part of the model they were implementing.

The themes that emerged from research question one were that the 5E model provided structure to the teaching and learning process and that the model required more time to develop and implement lessons. Research question two asked how middle and high school science teachers understand the purpose of learning and teaching science through the implementation of the 5E Instructional Model. The themes that emerged from research question two were that teachers perceived the purpose of the 5E model was to provide a student-centered teaching process and a more hands-on learning approach. Research question three was an inquiry question for the researcher in terms of the differences in the perceptions of middle and high school teachers.

Research question 1: Impact of 5E model

RQ 1: To what extent do middle and high school science teachers perceive that the use of the 5E Instructional Model impacts their classroom instruction?

When science teachers described the impact the 5E model had on their classroom instruction, multiple perceptions related to the development of structure to the teaching and learning process and the requirement of time needed to develop and implement 5E lessons.

Theme one: Provided structure to the teaching and learning process.

The theme of providing structure to the teaching and learning process emerged when participants were asked the following questions: What experiences have you had with the 5E Instructional Model? How do you use the principles of the 5E model in your own planning and teaching? Describe how the 5E Instructional Model impacts your instructional practices. Have there been any differences you have noticed, in the classroom that you would say are a result of implementing the 5E Instructional Model? This theme provided information about how teachers perceived that the 5E model helped them pace their lessons better.

Participants described their experiences with using the 5E model in their teaching of science and how it impacted their instructional practices. The descriptions of the participants indicated how they felt that the 5E Instructional Model helped to provide a structured teaching and learning process. From the responses provided by science teachers, 62% of the participants felt that the 5E model helped their organization and pacing of content and 38% did not explicitly respond that the 5E model added or took away from the teaching and learning process.

Seventy-five percent of the science teachers articulated how the model gave structure to their planning and lesson development to keep them on task but also make them teach with more intentionality. One participant articulated how the model improved their classroom management skills. Another participant described how the model helped their organization and improved students' overall structure of learning. Maurice felt that it keeps them aware of what needs to be taught and what is missing. He stated, "I feel like it's made me a better planner, like a better backwards design planner." Adrianne stated, "It has helped me with my organization and planning for lessons." Bethany, felt that her classroom management is pretty good now because of the use of the 5E Instructional Model. Becca stated, "I liked how the teacher framed each day using the 5E model so I used it then after; it made the content a little bit easier to teach and I did feel like the kids understood the content more." The participants' perceptions of the 5E model as providing structure corresponds to prior research findings that the 5E model can produce sustained influences on the teaching process and improvements in the instructional design process (Hu, Gao, & Liu, 2017).

Theme two: Required more time to develop and implement lessons.

The theme, required more time to develop and implement 5E lessons, provided viable information about the lack of time science teachers perceived they had to effectively implement the 5E model. Eighty-eight percent of participants articulated that there was a lack of consistency in instructional practices, and teachers were not afforded real opportunities to master specific strategies. They felt as if time was not being maximized or valued due to the lack of consistency in instructional practices. Participants' perceptions indicated that they tried to implement the model in some way, but the majority articulated that they did not use the model to its full extent because one phase of the model can take 2-3 days based upon instructional time given in each school building. Similarly, Fitzgerald (2019) identified barriers to implementation of new practices which included time restrictions.

The researcher felt this to be a profound theme that emerged from research question one due to previous research findings. Bybee (2014) suggested that the best use of the 5E instructional model is a unit of two to three weeks, using each phase as the basis for one or more lessons. Based upon science teachers' responses, time limitations caused a majority of the participants to not use the 5E model to its full extent because the lessons required a lot of time for planning and implementing. Antwon stated, "Sometimes the lessons provided in the portal are what I use for the Explore, but that can take 2-3 days by itself due to time limitations." Maurice stated, "One "E" from the model can take

1-2 days if not more.” Others described how they would only do parts of the model that were semi-related to parts of the Excellence School District’s Instructional Framework. This was a way for them to implement the model in some way and still manage the time needed to teach specific content before End of Course Assessments or Common Formative Assessments.

Research question 2: Purpose of the 5E model.

RQ 2: To what extent do middle and high school science teachers understand the purpose of learning and teaching science through the implementation of the 5E instructional model?

Participants described their perceptions of the purpose of teaching and learning through the implementation of the 5E model. Participants described how they perceived that the 5E model sets the framework for students to actually be scientists. The themes that emerged from research question two were that teachers perceived the purpose of the 5E model was to provide a student-centered teaching process and a more hands-on learning approach. Students are expected to use evidence from claims and argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits when conducting investigations, testing solutions, resolving questions, and creating models (NRC, 2012). Students are expected to collect data from their investigations in order to identify any patterns and relationships. Data collection should also allow students the opportunity to communicate findings and results with other students and even their teachers (NRC, 2012).

Theme Three: Provided Student Centered and Hands-On Instruction.

Theme three related to teachers' perceptions that the purpose of implementing the 5E Model was to provide more student-centered instruction and hands-on learning for students in science. This theme emerged from interview questions 1, 3, and 6. The descriptions of the science teachers indicated that because teachers were aware of the student-centered learning and hands-on approach, they began to shift their lesson planning to meet these teaching and learning outcomes and personalize learning for students. As Bybee (1997) noted, learning through the use of the 5E Instructional Model allowed students to have a personalized learning experience. Personalized learning models seek to adjust the learning experience of students based upon their strengths, needs, and interests (Herold, 2017).

Participants' perceptions related that the purpose of the 5E model was to provide a more student-centered instructional strategy that would allow students to act and think as scientists. Students at any grade level should be able to ask questions about their learning (NRC, 2012). This is the beginning stage of science and engineering. Asking questions and defining problems includes students asking questions about data, claims that are made, and proposed designs. "Whether engaged in science or engineering, the ability to ask good questions and clearly define problems is essential for all students" (NRC, 2012, p. 56).

Participants perceived the purpose of the 5E model was also to provide a hands-on approach to science learning. The shift in instructional practices in science education was due to the need for science to be taught as a practice and not for simple rote memorization. The researcher's notes indicated how most participants felt that the 5E model was designed to make students practice science more and to think critically. Participants described how students were retaining enough information to pass tests but not to actually apply their learning to real world happenings. Perceptions articulated by science teachers related the need for students to be more hands-on in science learning because it would give students more experience with scientific topics. Teachers' perceptions are some of the most significant factors that affect the teaching and learning process. Their perceptions tend to alter the perceptions of the learners, the learning atmosphere and learners' attitudes towards learning (Elmas & Aydin, 2017). Therefore, it is important that teachers see the value in the work they are doing and its importance to instruction or they may not implement it correctly. Teachers' perceptions about science, teaching science and learning science directly influence their classroom decisions and actions about teaching science (Busher & Tas, 2012).

Research Question 3: Comparing Middle and High School Teachers' Perceptions

RQ 3: To what extent do the perceptions of middle and high school science teachers differ in regards to their preparation for implementation of the 5E instructional model?

To answer research question three, Gaines' Framework was used to contrast the perceptions of middle and high school science teachers. Gaines' Conceptual Framework was established on the perceptions and understanding of teachers implementing the 5E instructional model in science instruction.

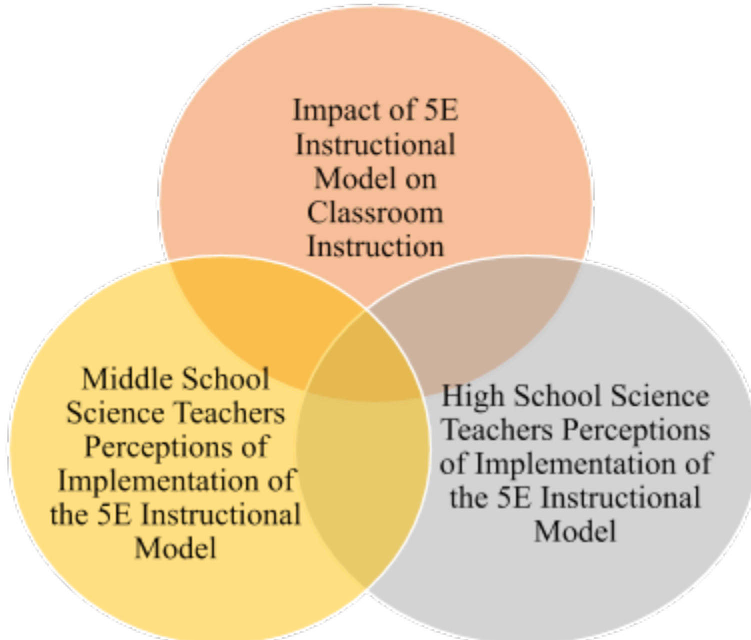

Figure 1. Implementation and Perceptions Framework

The differences in perspectives of middle and high school teachers were analyzed to determine if perceptions, resources, time, and support had an impact on the implementation and use of the 5E model. The researcher believed it to be important to compare and contrast the perceptions of middle and high school science teachers to determine if there are similarities or differences that can help make a connection for effective use of the instructional model. In prior research, high school science teachers reported a higher degree of motivation to use science and engineering practices. Teachers felt more prepared to implement the practices, and enacted modeling instruction at higher rates than middle school teachers (Haag & Megowan, 2015).

The researcher determined that there were no differences in perceptions, but multiple similarities between middle and high school science teachers. Antwon and Maurice who were middle school science teachers, perceived that the 5E Model was designed to allow students the opportunity to critically think and learn science as a practice. These perceptions were similar to those expressed by the six high school science teachers. High school science teachers perceived that the 5E model had helped in improving their classroom management, which was the same perception as that of the two middle school science teachers. Both middle and high school science teachers perceived that the 5E Model provided structure and organization and had a positive impact on classroom instruction. The only difference between middle and high school science teachers was the instructional time allotted to middle school, which was 75 minutes, and high school, which was 55 minutes in the Excellence School District. Science teachers received four hours a week in the middle schools for collaborative planning while the high school science teachers' collaborative planning varied because most were not on the same planning as others. Most of the middle and high school science teachers had experience in collaborating through shared planning periods. Some of the middle and high school science teachers planned collaboratively and some individually. From a comparison of the researcher's notes and participant member checking, the researcher found that the difference in common planning times within a department was perceived as a barrier to implementation for high school science teachers.

All middle and high school science teachers perceived that the 5E model had a positive impact on their science classroom instruction, but there were time limitations that did not afford teachers the opportunity to implement the 5E model to its full extent. Bybee (2014) suggested that the best use of the 5E instructional model is a unit of two to three weeks, using each phase as the basis for one or more lessons. Using the model for a single lesson decreases the effectiveness of the individual phases due to shortening the time and opportunities for challenging and restructuring of concepts for learning (Bybee, 2014). Using the model for an entire program would maximize the time and experience of the individual phases; however, the expectation for student experiences and outcome of the phases loses its effectiveness (Coe, Aloisi, Higgins, & Major, 2014)

The researcher concluded that there were no differences in perceptions of middle and high school science teachers on the impact of the 5E model in their science instruction. Participants perceived there to be a lack of consistency in instructional strategies and lack of support to ensure effective implementation of the 5E model.

Limitations of the Study

The researcher conducted the study in the Excellence School District. The participants were chosen using purposive sampling to include those with first-hand knowledge of teaching using the 5E Instructional Model and experience in teaching using other instructional practices. When training was provided for the 5E Instructional Model, it was after the 2017-2018 school term had already begun. Department chairs were used as participants in the initial 5E Instructional Model training. Teacher training at each middle and high school was through redelivery from their department chairs. The teacher training was expected to take place within a month's time frame following the initial training of department chairs at each school. The researcher perceived that because of the use of a train-the-trainer model, trustworthiness would be impacted. Training is a systematic way to improve the performance of employees, and it provides a link between job requirements and the current job specification of the employees (Hajjar & Alkhanaizi, 2018). However, training must be delivered with fidelity to have a positive impact. Often times, neutral perspectives of training are developed based upon the relationship of the trainers and the trainees. From participants' descriptions of their training on the use of the

5E model, it was determined that there was a lack of fidelity in the training. Participants described how there were no evaluations to observe and provide feedback to teachers to ensure proper implementation. There was also a lack of involvement from building level instructional leaders. Both middle and high school teachers perceived this to be highly important to the implementation process.

The researcher perceived that the ability to make contact with the superintendent, principals and science teachers in the selected district influenced the study. The influence came from the researcher originally wanting to conduct the study in their former school district. The district had completed its first full year of implementation of the 5E model, and it was the primary instructional focus. The researcher also played a role in training other teachers on implementing the 5E model in their former district and saw improvements in science instruction due to its' implementation. Although the researcher was not able to conduct the study in their former school district, the researcher realized that similar processes had taken place in their current school district for implementation of the 5E model. The difference was that although the Excellence School District used the 5E model in model lessons on their curriculum portal, science teachers were not speaking the language of the 5E model. This raised concerns with the researcher to further investigate the phenomenon. The researcher perceived that their current employment in the Excellence School District provided an opportunity to easily reach out to the superintendent, principals, and science teachers to conduct the study.

Getting each science teacher to volunteer was difficult. The researcher made multiple attempts to contact teachers in order to complete as many interviews as possible; however, due to the Covid-19 crisis, many potential participants did not want to take on any other activities. The Covid-19 crisis did afford the opportunity to conveniently interview participants via Google Meet, which the researcher believed would make it easy for those who chose to participate in the study. However, during the time that the initial invitations were emailed, most potential participants were preparing to begin virtual learning which had caused a lot of undue stress on teachers. Of the 53 initial emailed invitations that were sent, many of the potential participants simply stated that they did not know what the 5E Model was. The researcher felt that there was not a fair representation of participants because of these factors, and the researcher felt this to be a limitation to the study because it decreased the participation rate and the researcher intended to have at least 12 to 14 participants with equal representation from middle and high schools in the district.

Implications of the Study

The researcher in this study provided authentic descriptions from science teachers as they reflected on their use of the 5E Instructional Model in science instruction. The teachers' perceptions and the interpretation of their feedback contributed to the examination of the perceptions of middle and high school teachers in regard to the implementation of the 5E Instructional Model. Science teachers were not implementing the 5E Instructional Model with fidelity due to the lack of perceived instructional time and support from instructional leaders. A gap existed between teachers' understanding of the 5E model and the expectation of implementation of the work. Participants demonstrated knowledge and understanding of the intent and purpose of using the 5E Instructional Model in science instruction, but they lacked understanding of the importance of implementing the full aspect of the model.

The decision to use the 5E model in parts and not as a whole were due to the feelings of no real expectation being set in some school buildings and no evaluation methods to ensure fidelity. An implication for instructional leaders would be the need for reflection and intentionality when determining the levels of autonomy teachers should have in their instructional practices and decision making for instruction. This indicates a need to provide teachers with ongoing professional learning and direct support beyond the ideals and expectations for implementing new instructional practices.

Science teachers' perceptions were guided by the desire of structure in the process of implementing new instructional strategies. Follow up strategies and evaluations should be included in the implementation process to ensure that science teachers are implementing instructional strategies appropriately to see the full outcome of student achievement. Many felt that the use of the 5E model provided structure to their teaching and learning process.

Implications for district, state, and legislative leaders include the need to provide consistent implementation of instructional practices that allow teachers appropriate time to master required tasks. Teachers perceived that there was no consistent practice, but multiple practices which did not bring value or purpose to teachers' need to follow specific instructional practices. Overall, teacher perceptions were to do enough because the model was present on the district's curriculum portal, but not implement it with fidelity because building level instructional leaders were not pushing the need to use the 5E model. District level instructional leaders should work with building level instructional leaders to ensure that they are knowledgeable of what instructional practices science teachers are required to put into practice in their instruction. This could very well be an implication for all other content areas outside of science.

Recommendations for Future Research

1. What are the best practices for the implementation of new instructional strategies?" From the study conducted, the researcher questioned best practices for implementation of the 5E Instructional Model. Many of the participants perceived that there was a lack of consistency in instructional practices. Participants felt that it was important to become proficient in the instructional practices in place to truly see a positive outcome. They wanted to "master" what was already required of them before moving on to the next top strategy. When implementing new practices, participants described their needs for structure, order, and clarification of expectation from building and district level instructional leaders.
2. What are effective evaluation measures to ensure that new instructional practices are implemented with fidelity? This study revealed that teachers were not implementing the 5E model with fidelity for many reasons based upon individual perceptions. Participants described their typical day of using the 5E model and identified how they only used parts of it. Many thought that it should be aligned with the instructional framework that the district provided to all teachers, but it was found to not be similar to the framework of the 5E model. Participants used the 5E model because it was on the curriculum portal, but they did not hold true to fully implementing the model in science instruction. They felt that no one followed up to ensure that they were implementing the model or evaluating them.

3. The effectiveness of the “Train the Trainer” Model. This aligns with the previous recommendation and fidelity. It is important to look at how effective the “Train the Trainer” Model is and if the trainers are training teachers with fidelity. This can also have an effect on teachers’ perceptions of implementing new instructional practices.
4. What support do teachers need to effectively implement new instructional strategies? Participants perceived that there was a lack of support from instructional leaders during the implementation process of the 5E model. Future research on the support teachers perceive is needed during the implementation process will help to give teachers a voice on what they feel they need.
5. The researcher did not extend the invitation for participation in the study to Gifted and Special Education Teachers. The researcher believes that future research on the perceptions of Gifted and Special Education teachers and the implementation of the 5E model would be beneficial. It would provide insight to teachers who teach to specific learners and student accommodations.

Dissemination of the Findings

The purpose of this study was to examine the perceptions of middle and high school science teachers in regard to the implementation of the 5E Instructional Model. The researcher hoped to provide building and district instructional leaders with information necessary to effectively implement new instructional practices by giving voice to middle and high school science teachers through their perceptions and experiences of teaching using the 5E model. The researcher intends to share the findings of this study with the superintendent of schools, chief academic officer, district research team, and district instructional leaders. This dissertation will also be available in the Columbus State University's library system and attempts will be made to publish the results in peer reviewed journals.

Conclusion

Participants in this study provided valued insights into how they perceived the use of the 5E model in science instruction through their personal experiences during the implementation of this new instructional strategy. Participants' perceptions revealed a gap in the process of implementation of new instructional practices and the attitudes teachers have towards the implementation process. Some participants described their willingness to implement new instructional practices because of what had been provided by district level instructional leaders. Others described their willingness to implement new instructional practices on their own terms because of the lack of structure and follow up from building and district level instructional leaders. Participants who felt in favor or indifferent to the implementation of the 5E model all agreed that its implementation process had developed a structure and order to their teaching practices and students' organization of thoughts. Participants felt the 5E model helped the teaching and learning process by providing structure needed for classroom management, pacing, and organization at the teacher level. Participants in the middle and high school grade levels both believed that the 5E model required more time to develop and implement, which is time that many perceived they did not have.

Lessons in the curriculum portal provided to teachers by the district were modeled after the 5E model, but some participants did not feel that building level and district instructional leaders supported this practice because of the lack of evaluation and follow-up teachers received. Teachers also perceived it to be okay to implement the 5E model in science instruction without fidelity. These perceptions were because of the lack of time, resources, and clear expectations from instructional leaders. Although there were perceptions of little time for implementation, participants perceived the use of the 5E model to have an impact on student learning. Participants believed that the use of the 5E Instructional Model provided student-centered hands-on learning. Participants believed that it required students to actually "do" science. As demonstrated by the teachers' feedback in this study as well as the literature reviewed, the implementation of the 5E model in the Excellence School District has had positive impacts on students and teachers but could use some refining during the actual implementation process.

Science teachers had to adjust their mindsets to learning new instructional practices that would help shift the paradigm of science education. Science teachers had to shift their thinking from teaching science as just merely facts and make a push to teach science more as a practice to meet the needs of all students and increase their achievement levels. The skills and mindsets science teachers had related to the implementation of new instructional strategies are not natural to all educators. Science takes more practical teaching and learning to gain a full understanding of what is being taught. Instructional leaders who require such implementations in instruction or any other educational reform are responsible for facilitating the implementation process and ensuring that all science teachers thoroughly understand the process. Instructional leaders are responsible for evaluating and following up with teachers to ensure fidelity in the process when new instructional practices are being implemented.

As an experienced educator, the one thing I have always been in favor of is structure and support from my leaders. Just as students want discipline, but are not always in favor of it, the same is true for teachers. We may not always agree with everything that is mandated of us, but we will do it if we understand the purpose and value of doing it. I believe that many of the participants did not implement the 5E model to its full extent because of the perceived lack of expectations. There was no one in place to evaluate and follow through with the science teachers' implementation process. From experience and from being a paradigm shifter in educational settings, I have always learned that teachers will not do much when they feel it has no value because there are so many other tasks teachers are focused on completing.

Based upon the feedback from science teachers and their experience with implementing the 5E Instructional Model in science instruction, one question that still remains is, "What are the best practices for the implementation of new instructional strategies?" For the Excellence School District the question would also be, "How should the implementation process for new instructional strategies look in our district?" Teachers should also be included in this conversation because they will be able to provide authentic perspectives on what is working and what is not. Often times, teachers are almost never in the mixture of those who make decisions, but they are the ones who are mandated to see specific tasks through. The overall impact of the 5E Instructional Model on science instruction was positive with the little implementation teachers did do. Thinking further, building level and district level instructional leaders should look at the increase in student achievement and other positive gains that teachers, students, and schools could possibly gain from using the 5E model in its' entirety. This will focus on teaching and learning science as a practice and increasing student achievement in science which were both reasons for the shift in science education over the years.

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APPENDICES

Appendix A

Informed Consent for School Principals, Middle and High School Science Teachers

INSTITUTIONAL REVIEW BOARD

Informed Consent Form

You are being asked to participate in a research project conducted by Erica Gaines, a student in the Doctoral Program for Teacher Education at Columbus State University. This study is supervised by Dr. Deborah Gober.

I. Purpose:

The purpose of this project is to examine the extent of middle and high school science teachers' perceptions of their implementation of the 5E model and its impact on instructional practices.

II. Procedures:

If you agree to be in the study, you will participate in individual semi- structured interviews. Summary data from this research could be used in future presentations or future research; however, no data will be used that would identify the participants. Participants will complete demographics information and answer general questions about their attitudes/understanding of the 5E Instructional Model. Face to face individual semi- structured interviews will take approximately 45 to 50 minutes to complete. The interview will take place at a time designated by the participant. The face to face interviews will be recorded using an electronic device. After the interviews, a transcript of the interview will be emailed to the participant to check for accuracy.

III. Possible Risks or Discomforts:

There are minimal risks when participating in the study. There is the potential loss of confidentiality, because the researcher cannot guarantee that participants will not share information from the survey or individual interviews. The researcher will take the following precautions to minimize the level of social risks by allowing participants to withdraw or limit their participation if they become uncomfortable, allowing participants to request that the audio recording be paused at any time there is a feeling of discomfort, asking participants to agree to the importance of keeping information discussed during the interview confidential.

IV. Potential Benefits:

The potential benefits of this research for middle and high school science teachers and the school district will be to allow opportunity for the Science Coordinator and Curriculum Specialist to better assist science teachers in the implementation process of future instructional practices and ways to improve the use of the 5E Instructional Model. If there are or are not any concerns, this gives the Science Coordinator and Curriculum Specialist something measurable in relation to concerns about how new instructional practices are implemented.

V. Costs and Compensation:

Participants will not be compensated for responding to the web-based survey or participating in an interview.

VI. Confidentiality:

The researcher will ensure that participants' data remain confidential in the following manner: (1) storing confidential data in password-protected files on a password-protected device; (2) removing email and IP addresses from the raw data file; and (3) properly deleting, shredding, and disposing of all documents, reports, and electronic files with identifiable information one year after the completion of the study.

VII. Withdrawal:

Your participation in this research study is voluntary. You may withdraw from the study at any time, and your withdrawal will not involve penalty or loss of benefits.

For additional information about this research project, you may contact the Principal Investigator, Erica Gaines at 561-628-4817 or gaines_erica@columbusstate.edu. If you have questions about your rights as a research participant, you may contact Columbus State University Institutional Review Board at irb@columbusstate.edu.

I have read this informed consent form. If I had any questions, they were answered. By signing this form, I agree to participate in this research project. [If participation is dependent upon the participant being 18 years of age or older, you must include a statement here confirming the age.]

____________________________________ _______________________

Signature of Participant Date

Appendix B

Interview Protocol

Teacher Perceptions of Teaching Science Using the 5E Instructional Model Science Teachers Interview Protocol Questions

Adapted from Sizemore (2018) Interview Protocol Questions

1. What do you know about the 5E Instructional Model?

    a. What is the purpose of the 5E Instructional Model?

    b. What are the guiding principles of the 5E Instructional Model?

    c. What do you perceive to be the pros and cons?

    d. Would you recommend the 5E Instructional Model to other teachers? Why or why not?

2. What experiences have you had with the 5E Instructional Model?

    a. How did you hear about the 5E Instructional Model?

    b. How long have you worked with the 5E Instructional Model? In what capacity?

    c. How do you use the principles of the 5E model in your own planning and teaching?

    d. What is the expectation for utilizing the 5E Instructional Model at your school?

3. Do the teachers you work with use the entire structure of the 5E Instructional Model?

    a. Approximately what percent of the teachers, in the school where you work, are knowledgeable about the 5E Instructional Model? How do you know?

4. Describe your typical classroom day, where the 5E Instructional Model principles are used.

a. Describe how the 5E Instructional Model impacts your instructional practices.

b. Have there been any differences you have noticed, in the classroom, that you would say are a result of implementing the 5E Instructional Model? Instructional? Behavioral?

5. How is the entire structure of 5E Instructional Model utilized in your school?

6. When planning lessons, how do you plan for the diversity of students in the classroom?

a. How do you utilize the 5E Instructional Model during planning?

b. Has there been any differences you have noticed, in lesson planning, that you would say are a result of implementing the 5E Instructional Model?

c. Describe the process you follow to plan for the diversity of your students.

d. How has the implementation of the 5E model influenced your planning for diversity?

e. What is the process for collaborative planning in your school?

Appendix C

Demographics Information Questionnaire

COLUMBUS STATE UNIVERSITY

Demographics Survey

1. Did you teach science in the current school district in the 2017-2018 school year?
Yes
No

2. Did you teach science in the current school district in the 2018- 2019 school year?
Yes
No

3. Did you receive training and implemented the 5E Instructional Model in 2017-2018 and 2018-2019 school year?
Yes, the 2017-2018 school year
Yes, the 2018- 2019 school year
Yes, both school years
No

4. What is your gender?
Female
Male
I choose to not specify

5. What race/ethnicity best describes you?
White or Caucasian
Black or African American
Hispanic or Latino

Asian or Asian American
American Indian or Alaska Native
Native Hawaiian or other Pacific Islander
Another race

6. Please select your years of experience:
0-3 years
4-6 years
7-10 years
11-13 years
14-17 years
17+

7. How many years have you taught using the 5E Instructional Model?
0-3 years
4-6 years
7-10 years
11-13 years
14-17 years
17+

8. What grade level do you teach?
Middle School (6-8)
High School (9-12)

9. Please provide your contact information:
Name
Email Address
Phone Number

Submit Demographics Survey

Appendix D

Approval for Permission to Conduct Study

Office of Data and Research

Clarke County School District
Better Every Day

Xernona Thomas, Ed.D.
Superintendent

James Barlament
Director

September 24, 2020

To: Columbus State University Institutional Review Board

The Clarke County School District has approved the research proposal submitted by Erica Gaines entitled, “Teaching Science using the 5E Instructional Model.” The researcher will explore the impact of middle and high school Science teachers’ use of the 5E Instructional Model in classrooms at Burney-Harris-Lyons Middle School, Clarke Middle School, Coile Middle School, Cedar Shoals High School, and Clarke Central High School. The results of the survey will benefit the school district as we look to strengthen the use of inquiry-based approaches in science classrooms and better serve all students. Research activities will focus on surveys of and qualitative interviews with science teachers.

Ms. Gaines will seek participant consent, notifying participants of research ethics, and agrees to not share any personally identifiable information on participants. The CCSD Office of Data and Research approves Ms. Gaines’ protocols to protect privacy and maintain the integrity of research in the district.

On behalf of CCSD, we look forward to working with Ms. Gaines on this research project, and eagerly await the results to further guide our work.

Sincerely,

James Barlament
Director of Data and Research
Clarke County School District

Appendix E

CSU IRB Approval

Institutional Review Board
Columbus State University

Date: 10/07/2020
Protocol Number: 20-093
Protocol Title: Teacher Perceptions of Teaching Science Using the 5E Instructional Model

Principal Investigator: Erica Gaines
Co-Principal Investigator: Deborah Gober

Dear Erica Gaines,
The Columbus State University Institutional Review Board or representative(s) has reviewed your research proposal identified above. It has been determined that the project is classified as exempt under 45 CFR 46.101(b) of the federal regulations and has been approved. You may begin your research project immediately.
Please note any changes to the protocol must be submitted in writing to the IRB before implementing the change(s). Any adverse events, unexpected problems, and/or incidents that involve risks to participants and/or others must be reported to the Institutional Review Board at irb@columbusstate.edu or (706) 507-8634.
If you have further questions, please feel free to contact the IRB.
Sincerely,

Andrew Dorbu, Graduate Assistant

Institutional Review Board
Columbus State University

*** Please note that the IRB is closed during holidays, breaks, or other times when the IRB faculty or staff are not available. Visit the* ***IRB Scheduled Meetings*** *page on the IRB website for a list of upcoming closures. ***