A PROGRAM EVALUATION OF MIDDLE SCHOOL SCIENCE TEACHERS' PERCEPTIONS AND INSTRUCTIONAL PRACTICES WITH THE NEXT GENERATION SCIENCE STANDARDS: SCIENCE AND ENGINEERING PRACTICES

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Dedication

This dissertation is dedicated to my late father, Mr. Clarence Glenn, who believed in my dreams. It is also dedicated to my son, Andrew McCurvin, Jr., who has traveled this journey with me through the trenches. He refers to me as his hero, and I am honored to call him my son. Through me, I hope you see that "All Dreams Can Come True" with commitment, dedication and sacrifice. I love you.

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Acknowledgements

The last three years have been an incredible journey. When I started in 2015, I was naïve and had no idea the amount of time and work that would go into completing this journey. It has been, by far, the most challenging and most rewarding intellectual experience of my life. There were many who supported my dream and assisted in the process.

First and foremost, I would like to thank GOD for giving me the strength and the direction to know that I am the author of my book and, through Him, I can achieve my heart's desire. To my mother, who is the pillar of my life. She's a fighter and has imbued me with her fighting spirit. Thank you, Mom, for being by my side and for supporting me through every stage of my life. To my son, Andrew, who is my greatest accomplishment. I love you more than any word can describe; you give my life meaning. You keep me grounded and focused on my purpose in life.

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To my Uncle Chuck, my biggest fan, the thought of you makes my heart smile. Thank you for always being you. Your love and support are immeasurable. I am grateful to have you in my life. To my family and friends who cheered me on along the way, it was both motivating and inspiring. Thank you for your love and support. I am blessed and grateful to have you in my life.

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To the principals and the twelve teachers that participated in this study, I salute you for adding to the research on NGSS, your dedication to children inspires me to continue to want to help all teachers teach like you.

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Abstract

The Next Generation Science Standards (NGSS) is the most recent reform in science education across the United States. The NGSS demands a shift in both teaching and learning. Yet there is no direction on how teachers are to implement this shift in their classrooms. This mixed-methods study examined 12 middle school teachers' perceptions and the instructional practices within the NGSS Science and Engineering Practices (SEPs) by using interviews and classroom observations. Findings suggest that there was a shift in instructional practices and a varying degree of implementation of the eight SEPs. The data analysis identified ongoing needs related to specific professional development. The researcher concluded that district leaders and school principals need to provide tangible supports to teachers in order to successfully meet the demands of this new vision of science education.

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CHAPTER 1

INTRODUCTION

Background

Science learning in middle school is a critical time to develop a strong understanding and appreciation for science, yet science education in the United States is in crisis (Mesa, Pringle, & King, 2014). American students lag behind their peers internationally in both science and math. This underperformance is highlighted on international assessments such as Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS; Organization for Economic Co-operation and Development [OECD], 2010). The 2012 PISA ranked the United States as 23rd in science out of 65 OECD educational systems. Results from the most recent National Assessment of Education Progress (NAEP) indicated that a third of eighth-graders scored below basic on the 2011 NAEP Science assessment. On the 2016 Maryland State Assessment (MSA) in science, 35% of the eighth-graders scored basic, 60.8% scored proficient, and 4.2% scored advanced (Maryland State Department of Education, 2016). The MSA is a standards-based test in reading, mathematics, and science. The MSA for science measures a student's science achievement in both fifth grade and eighth grades.

As an effort to improve middle school students' performance in science, there is a need to review and analyze the middle school science curriculum. According to National Research Council ([NRC], 2007, 2012), studies of middle school curricula, the current, middle school curriculum is inadequate for the purpose of building knowledge and providing students with engaging opportunities to experience how science is done. The Maryland curriculum contains a sequence of content that teachers are to teach and students are to learn to be considered proficient in science.

Teachers are teaching content in isolation with low mastery. The lack of uniformity in content quality across the 50 sets of state standards has resulted in curricular frameworks and textbooks that are unfocused and ineffective in supporting student learning (Schmidt, McKnight, & Raizen, 1997). Students learn several topics but have no depth of knowledge in any area of science. These disjointed and isolated topics do not allow students to apply knowledge outside the context of the classroom; there are no real-world connections. In most classrooms in the U.S., teachers' instruction attempts to support students in learning science through participating in disconnected science activities (Carey, Evans, Honda, Jay, & Unger, 1989; Windschilt, 2008).

The U.S. is the only country assessed using the PISA and TIMSS that does not have a nationalized curriculum. The development of *A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas* (NRC, 2012) along with the Next Generation Science Standards (Achieve, Inc., 2013b) aims to guide science education reform efforts. Based on decades of research, these documents indicate that K-12 classroom instruction should focus on the intersection of scientific and engineering practices, disciplinary core ideas and cross-cutting concepts (NRC, 2012). Three-dimensional learning shifts the focus of teaching and learning to intertwined inquiry and content, while making meaningful, real-world connections.

In 2013, the state of Maryland adopted the Common Core State Standards (CCSS) along with the NGSS (Achieve, Inc., 2013a), a new approach to address middle school science education in the U.S. The standards are based on *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012). Students are expected to learn how and why natural science phenomena occur through the three dimensions of the NGSS: practices, crosscutting concepts, and core ideas. The most significant change between the old standards and the NGSS are the eight Science and Engineering Practices (SEPs). These practices are important because they are directly related to a thorough understanding of the instruction needed to meet the demands of this transformational vision of middle school science education. The NGSS shifts the teaching of science in key areas, including rigor, sequencing of content, and incorporation of engineering. To create a rigorous learning environment and provide students with a deep meaningful understanding of science concepts, as specified by the NGSS, teachers must use strategies that support students in making sense of multiple science concepts. However, the reform does not describe how teachers are to change their instruction when implementing the new standards (Crispeels, 1997; Darling-Hammond, Amerin-Beardsley, Haertel, & Rothstein, 2012; Elmore, 2000; Fullan & Knight, 2011; Hargreaves & Fullan, 2012; McDonnell, 1994; McLaughlin, 1987; Meyer & Rowan, 1978; Spillane, Reiser, & Reimer, 2002). As part of this reform in Maryland, school districts face challenges in changing their entire science program to include curriculum, instruction, and assessments aligned to the new standards.

Teachers are the key to successful science reform. Unfortunately, teachers are not actively involved in the reform process. Yet, they are expected to design and implement meaningful instruction that meets the needs of the new standards. Training teachers to change practices is critical in the reform efforts. The NGSS aim to increase rigor in science instruction. However, neither the Framework nor the NGSS articulates how teachers should make shifts in instructions to accommodate the implementation of the vision. Teachers are left to make sense of the reform, which can ultimately challenge implementation in the classroom (Elmore, 2004; McLaughlin, 1987).

Program Description

The adoption and integration of the NGSS have been slow processes in the state of Maryland. The large urban school district selected for this study is transitioning to the implementation of the NGSS by adopting new commercial materials along with developing new district curricula. Early in the planning phase, the district decided to adapt and to modify the past middle school curriculum as the best option for reform implementation; however, given the curricular differences and the demands of the NGSS, the lack of coherence among curricular materials become evident. Creating new middle school curricula while transitioning poses significant obstacles to effective NGSS implementation. The school district science office chose to stagger the incomplete curriculum throughout the year, putting the teachers in a panic. By midyear, this approach left the design and integration of the curriculum up to the individual teachers. The NGSS differs from the previous standards, not only in structure, but also in content. Due to the complexity of the new standards, teachers need time to learn and develop a deep understanding of the vision and goals of the NGSS. Proper implementation of the NGSS rests heavily on teachers' ability to understand the demands of the initiative and to implement them in their classrooms.

Context. This program evaluation used purposeful sampling to select participants, middle school science teachers within a large urban district in the state of Maryland. Middle school science teachers were selected from three middle schools within the district. School A has a diverse population of 788 students. The Maryland State Report Card reveals that 38.8% of the population qualifies for free and reduced-priced meals; fewer than 5% are Limited English Proficient (LEP) students; and 11.5% are Special Education (SPED) students. There are over 60 instructional staff members: 25.5% have a standard professional certification, 48.7% have an advanced professional certification, 2.5% are resident teachers, and 15.4% are conditional teachers. School B has a diverse population of 573 students. The Maryland State Report Card reveals that 54.6% of the population qualify for free and reduced-priced meals; fewer than 5% are LEP students; and 11.7% are SPED students. There are over 50 instructional staff members: 20% have a standard professional certification, 53.3% have an advanced professional certification, 6.7% are resident teachers, and 3.3% are conditional teachers. School C has a diverse population of 797 students. The Maryland State Report Card reveals that 58.9% of the population qualify for free and reduced-price meals; fewer than 5% are LEP students; and 9.4% are SPED students. There are over 70 instructional staff members: 25.6% have a standard professional certification, 48.7% have an advanced professional certification, 2.6% are resident teachers, and 15.4% are conditional teachers. Over the past decade, the leadership structure in this large urban school district has changed four times.

Science teachers in these middle schools teach Integrated Science, which provides a sequence of physical science, chemistry, life science, earth science, and environmental science topics within each grade level consistent with the progression of core ideas from the NGSS. The science teachers collaborate on grade-level teams to develop multi-day units identifying science and engineering practices, details of lesson activities, and key science concepts. However, authentic planning and collaboration are inconsistent, creating challenges for making meaningful changes. Collaboration creates a professional learning community to share teaching strategies. Teachers working in groups with guidance from peers and instructional leaders have a better understanding of new policies. Too often changes and reforms are unsustainable, unobtainable, and unsupported. The “theory of sustainability”—which consists of environmental soundness, social justice, and economic viability—holds that if any of these three are weak or missing, the practice will not prove sustainable over time (Pascale, Millemann, & Gioja, 2000, p. 92).

The NGSS are intended to reflect a new vision for American science education. The three dimensions of the NGSS (practices, crosscutting concepts, and core ideas) demonstrate what is new in science education. Integration of the three dimensions demands students engage in authentic science that requires them to explore and discover science phenomena. The over-arching point not explicitly stated is how teachers are to align, design, and provide instruction to meet the needs of the science and engineering practices.

Description of the program. The NGSS is a shift in teaching and learning. A shift from the language and standards of inquiry in the *National Science Education Standards* (NSES) to the language of practice, as well as becoming familiar with engineering standards (Pratt, 2013), is essential for successful implementation. Teachers are facing challenges in restructuring their teaching around the SEPs in the NGSS. The eight science and engineering practices of the NGSS (NRC, 2012) are:

1. asking questions (for science) and defining problems (for engineering)
2. developing and using models
3. planning and carrying out investigations
4. analyzing and interpreting data
5. using mathematics and computational thinking
6. constructing explanations (for science) and designing solutions (for engineering)
7. engaging in argument from evidence, and
8. obtaining, evaluating, and communicating information.

The eight practices are interrelated and teachers need to understand the practices and possess the ability to enact instruction in the classroom. These demands necessitate a significant shift in instruction. The NGSS, unlike prior science standards, are non-linear and require cohesiveness during implementation; thus, there is a need for high quality curriculum materials. The success of the NGSS might hinge on providing teachers with support related to understanding the goals of the NGSS and designing instruction to meet those goals (Garet, Porter, Desimone, Birman, & Yoon, 2001; Spillane, Reiser, & Gomez, 2006).

Given these drastic demands, empirical research related to teachers' understanding and enactment of the SEPs to meet these new goals is needed (Allen & Penuel, 2014; Moon, Michaels, & Reiser, 2012). To adequately meet the needs of the

NGSS, teachers must display content knowledge, pedagogical knowledge, and an understanding of the SEPs.

Overview of the Evaluation Approach

The evaluation focused on the implementation of the NGSS within three urban middle schools in Maryland. The NGSS puts forth a new vision for science education that calls for drastic shifts in teaching and learning. The Framework explains how incorporating the three dimensions (practices, crosscutting concepts, and core ideas in science instruction) are essential for developing a fundamental understanding of scientific principles. This study focused on the SEP component of the NGSS.

Program evaluation model. The program evaluation model followed the CIPP model developed by Daniel Stufflebeam (2002). The CIPP model outlines the (a) context of the science program, including an overview of background information on how science education is transforming; (b) inputs into the science education program, including the science program’s resources; (c) processes used in designing and delivering the science education program; and (d) outcomes for all stakeholders. The focus of the CIPP model in this program evaluation is the process component. The process component deals with program implementation. Figures 1 and 2 provide a logical model for the program.

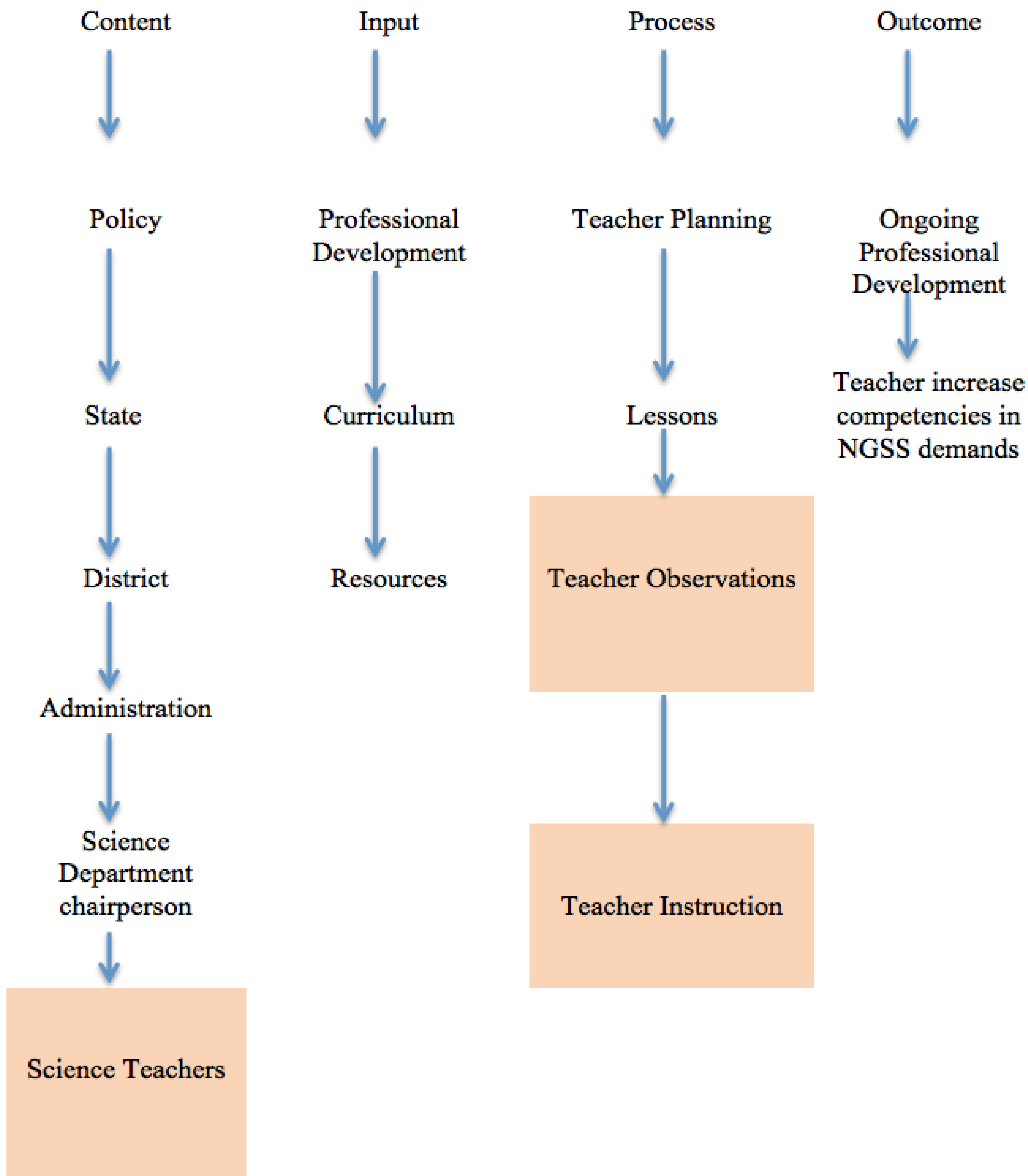

Figure 1. A logic model for science programs in an urban district in Maryland.

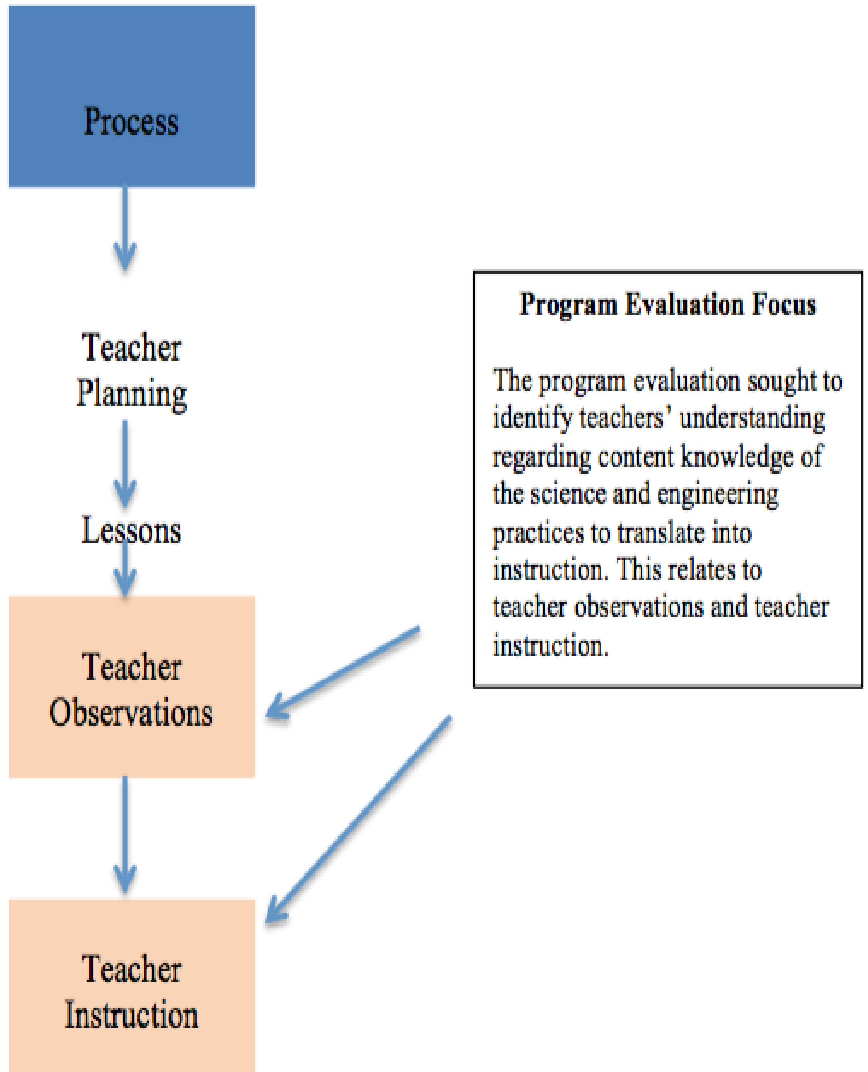

Figure 2. The process focus as related to the program logic model.

The purpose of the evaluation. The purpose of this program evaluation was to identify teachers' understanding and enactment of SEPs in their instruction. Due to the drastic shift in teaching and learning with the adoption of the NGSS, it is important to have the support of all stakeholders, particularly administrators and teachers in the implementation process. The purpose of the evaluation was to identify the instructional practices middle school teachers used to implement the SEPs. Findings from this study could inform the district and administration of the professional development needs of the middle school teachers. The results from this study are intended to inform and improve NGSS implementation efforts by local, state, and national policy-makers.

The focus of the evaluation. The NGSS aims to improve the level of rigor in science instruction (Achieve, Inc., 2013b). However, while the SEPs describe the broad context for learning content, the NGSS does not provide directions on how to design and implement instruction. The focus of this program evaluation was the process component of the CIPP: to identify teachers' understanding regarding pedagogical content knowledge of the SEPs.

Evaluation questions. Studies of policy implementation suggest that large-scale standards-based reforms are unsuccessful during implementation because districts and teachers must develop their interpretation about how policy relates to practice (Coburn, 2001; Elmore, 2004; McLaughlin, 1987; Spillane, 2004). The focus of this program evaluation was to identify teachers' content knowledge and pedagogical content knowledge related to SEPs. Four research questions guided this evaluation:

1. In a selected large urban Maryland school district, what are middle school science teachers' perceptions regarding instructional practices that needed to be modified to align with the NGSS and SEPs?
2. To what degree do middle school science teachers' perceptions regarding instructional practices align with key practices of the NGSS and SEPs?
3. What instructional practices do science teachers use to meet the demands of the NGSS and SEPs?

4. To what degree do instructional practices science teachers use align with key aspects of the NGSS and SEPs?

Definitions of Terms

- Alignment: Alignment refers to the extent to which curriculum standards, assessments and instruction are designed at a level of cognitive demands that allows students to meet learning targets (Webb, 2007).
- Coherence: Coherence refers to conceptual building of knowledge and skills over the course of lessons, units, or years of instruction. This is in contrast to asking students to learn discrete pieces of content (Achieve, Inc., 2013b).
- Common Core State Standards (CCSS): English Language Arts and Mathematics Standards that have been streamlined in many states.
- Curriculum: A program that comprehensively supports the content goals of a science class over large quantities of instructional time (e.g., semester, year). Curriculum includes all necessary components for instruction, such as lessons, assessment opportunities, and teacher guides (Achieve, Inc., 2013b).
- *Framework for K-12 Science Education*: The foundation report produced by the NRC that forms the basis for the NGSS. It calls for a new approach to science and educational research.
- Instruction: Planned and unplanned experiences provided by a teacher and intended to result in the acquisition of a set of intended learning outcomes for students (Gareis & Grant, 2008).
- Middle school: A school providing instruction for students in Grades 6-8.

- Middle school science teachers: Teachers who teach integrated science in Grades 6-8.
- Next Generation Science Standards (NGSS): New K-12 science standards developed by the NRC that are rich in content and practice, arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education.
- Science and Engineering Practices (SEPs): The practices are required for students to make sense of phenomena. They are both a set of skills and a set of knowledge to internalize. The SEPs reflect the major practices that scientists and engineers use to investigate the world and design and build systems. The eight practices outlined by NGSS are (1) redefining problems; (2) developing and using models; (3) planning and carrying out investigations; (4) analyzing and interpreting data; (5) using mathematical and computational thinking; (6) constructing explanations and designing solutions; (7) engaging in arguments from evidence; (8) and obtaining, evaluating, and communicating information (Bybee, 2014).
- Three-dimensional learning: What students experience in classrooms implementing the NGSS; should reflect developing and using elements of the three dimensions (practices, crosscutting concepts, and disciplinary core ideas), together, purposefully. Lesson and units aligned to the standards should allow students to actively engage in the practices and apply the crosscutting concepts to deepen their understanding of core ideas across science disciplines.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This literature review is intended to frame the research surrounding the purpose of this program evaluation—that is, to identify middle school teachers' pedagogical knowledge and implementation efforts about the Next Generation Science Standards (NGSS) and Science and Engineering Practices (SEPs). The chapter begins with the need for the NGSS within the 21st century, illuminating the history and development of scientific efforts in the U.S. and presenting the information in favor of the adoption of the standards. Next, I provide a synthesis of research that is relevant to teacher pedagogical content knowledge and SEPs. Finally, I present literature related to the demands of the NGSS, including (a) shifts in instruction; (b) cohesive implementation; and (c) high-quality curriculum materials, which include the key aspects of the NGSS.

Need for NGSS

An historical overview of science education. To develop an understanding of the need for NGSS and the current science standards that frame this study, it is important to look at the historical overview of the evolving nature of science education within the U.S. Long (1983) stated that educators should look to the past to discover what might be most effective in the future. Science education reform spans over five decades beginning in the 1950s with the launch of the first artificial satellite, Sputnik, launched in 1957 by the Soviet Union (Cadbury, 2006). After the Sputnik launch, Americans became concerned about the state of the nation's K-12 science and mathematics education. The post-Sputnik era pushed for a scientifically literate society. Scientific literacy is the knowledge and understanding of scientific concepts and processes required for a person to ask, find, or determine answers to questions derived from curiosity about everyday experiences (NRC, 1996, 2012).

The 1983 seminal report, *A Nation at Risk,* was one of the first national documents to call for a new breed of standards reform in science education. The authors of this report proposed linking accountability in states and schools to student assessments that were aligned with the reformed standards. Also, the report outlined the dire state of student achievement in the U.S. when compared to other countries (Gardner, 1983). Despite these facts, significant advances in the theory and practices of education in science and how to assess this learning have been made over the past decade; yet, how to successfully implement effective strategies to address this underperformance in science remains unclear (Duschl, Schweingruber & Shouse, 2007; Kirsch, Braun, Yamamoto, & Sum, 2007). Over the years, however, standards have continued to change and evolve.

Early development of standards for teaching science. In 1989, the American Association for the Advancement of Science published *Project 2061: Science for All Americans,* denoting long-standing competencies for science education reform in K-12 schools. In addition to competencies related to what students should understand and be able to do at the completion of K-12 education, *Project 2061* delineated conceptual structures and goals related to the benchmarks for the teaching of scientific inquiry (Barrow, 2006; Rutherford & Ahlgren, 1989) and conveyed science literacy as a content topic. The standards-based science reform follows the *Project 2061* era. The following decade, the NRC released the National Science Education Standards (NSES) featuring inquiry to ensure that teachers practiced scientific inquiry as a content topic (NRC, 1996, 2000, 2012). Although called national standards, the NSES served as an advisory document of guidelines for K-12 education; still, they had a significant impact on the governance of science curriculum and assessment. The NSES became a benchmark for state-level and national achievements in science education and promoted a greater dependence on standardized testing (DeBoer, 2000). Subsequently, the 2001 *No Child Left Behind Act* (NCLB) further emphasized standards, which states then began to adopt. NCLB was an attempt to use recommendations from *A Nation at Risk* to reform education practices, but this attempt had questionable success. The impetus for redesigning science standards at the national level was the significant underperformance of students in the U.S. on assessments of science literacy and reasoning. As previously stated, this underperformance was most notable on the international assessments, such as the PISA and TIMSS (OECD, 2010).

Development of the NGSS. The NGSS and accompanying *Framework for K-12 Science Education* (NRC, 2012) represent the most recent efforts of reform. One of the most significant changes in the NGSS from previous standards is the introduction of SEPs. These practices are important because they are directly related to a deep understanding of what science is, and they outline a framework for how science is used to create knowledge within the discipline. The National Science Teacher Association (NSTA) recommended the adoption and implementation of the NGSS as an effective, research-based approach to accomplish these goals and transform science education (Achieve, Inc., 2013b). The *Framework* refines and deepens the meaning of the term “inquiry-based science” by identifying a set of science and engineering practices. Despite being student-centered and inquiry focused, the NSES perpetuated a separation of science core ideas and practices. McCown, Driscoll, and Roop (1996) asserted that teaching must change from the methods of the past: “Teaching the way you were taught might be satisfactory if the nature of the school and the society they serve did not change and if the teaching practices of days gone by were uniformly effective” (p. 11). All stakeholders in education must embrace a paradigm shift that adopts reformed science teaching practices.

Research and previous attempts at reforming science education in the U.S. have led to the development of the NGSS. In 2009, a Carnegie Foundation commission of distinguished researchers and public and private leaders concluded that the nation’s capacity to innovate for economic growth and the ability of American workers to thrive in the modern workforce depends on a broad foundation of math and science learning (NGSS Lead State, 2013). Current science education research indicates that for students to authentically do science, practice and core ideas must be intertwined—something the NGSS encourages within the three dimensions (practices, cross-cutting concepts, and disciplinary core ideas; Achieve, Inc., 2013b). Since the goals of the NGSS are drastically different from the NSES, teachers need to develop a deep understanding of the goals of the SEPs. The NRC (2012) identified the need at the local, state, and national levels to increase content and pedagogical content knowledge for teachers implementing the new standards. The SEPs are identified not as separate learning goals that define what students should know about the process of science, but rather as ways of identifying the reasoning behind, discourse about, and application of the core ideas in science (Reiser, Berland, & Keyon, 2012). Previous researchers have shown how teachers’ goals, beliefs, and understanding about science education reform influence the ways they enact the reforms (Aguirre & Speer, 1999; Coenders, Terlouw, & Dijkstra, 2008; Crawford, 2007; Davis, 2008; Haney, Czerniak, & Lumpe, 1996; Keys & Bryan, 2001). This study focused on middle school science teacher's perceptions of NGSS and how such reform potentially impacted pedagogical practices.

Pedagogical Content Knowledge in Science and Engineering

Background on pedagogical content knowledge. In response to the NGSS, experienced teachers are required to make a significant shift in the content and manner in which they have been teaching; thus, modifications in the content knowledge and competencies will need to be made (Pruitt, 2014). Perkins and Reese (2014) cautioned educational leaders that these changes must be anticipated and acknowledged to best support teachers through the adjustment. Implementing an educational reform is a complex and continuous endeavor (McDonnell & Weatherford, 2016; Young & Lewis, 2015). As indicated by Stronge (2007), effective teachers must have sufficient knowledge of content and the teaching and learning process to appreciate these complexities.

Shulman (1986) first described Pedagogical Content Knowledge (PCK), which refers to the particular set of skills, or pedagogy, required to teach a specific content area. Beliefs about science teaching and learning cover the roles of the teacher and learner, how students learn science, and how to teach it. PCK is a knowledge base that enables teachers to make content understandable for their students (Shulman, 1986). Teachers provide appropriate methods, techniques, and materials in the process of teaching either as the source of information or as a guide during the learning process. Bissaker (2014) noted that teachers need knowledge to support appropriate learning opportunities that promote both meaningful engagement with the content as well as progression through inquiry-based learning. PCK is the most important component in identifying the role of the teacher in carrying out effective teaching (Ann, Kulm, & Wu, 2004; Ball, 1990; Magnusson, Borko, & Krajik, 1999; Nilsson, 2008). In order to understand PCK, teachers' knowledge, beliefs, and actions should be evaluated and understood (Baxter & Lederman, 1999). Observations are highly reliable for measuring PCK of teachers because observations reflect teachers' explanations, illustrations, actions, behaviors, and calculations in detail (Hill, Sleep, Lewis, & Ball, 2007). Ball (1991) succinctly stated, "Teachers cannot help children learn things they themselves do not understand" (p. 5). Preparing teachers to introduce the NGSS necessitates not only an increase in the use of science inquiry approaches but also application of specific content knowledge and PCK. Developing PCK is specific to the topic and is seen in the translation of effective instructional approaches that are suited to particular subjects (Crismond & Adams, 2012; Van Driel & Berry, 2012).

Pedagogical content knowledge within science and engineering teaching practices. The NGSS represent a drastic shift from the previous NSES (NRC, 1996) due to the integration of the SEPs. Historically in U.S. classrooms, science instruction has promoted the completion of curricular activities rather than sense-making, rarely taking students' prior knowledge into account, seldom pressing for evidence-based explanations, and often treating students' ideas as incongruent with canonical science (Alexander, Osborne, & Phillips, 2000; Banilower, Smith, Weiss, & Pasley, 2006; Barton & Tan, 2009; Horizon Research International, 2003; Maskiewicz & Winters, 2012; Roth & Garnier, 2007; Weiss, Banilower, McMahon, & Smith, 2001). The term "science practice" occupies significant airtime in current science education literature. This attention involves the NGSS, which frames students' learning expectations in terms of participation in science practices (Achieve, Inc., 2013b). Teachers face challenges while trying to implement science practices in their teaching. The shifts promoted within the NGSS require many teachers to enhance both their content knowledge as well as their PCK in order to enact SEPs in their classrooms.

Fostering a stronger foundation of science content knowledge and PCK in teachers is necessary to implement the SEPs. Engineering and science are distinct fields with different goals. Engineers focus on modifying the world to meet human needs and wants; scientists focus on studying the natural world to understand deeply how things work (Katechi, Pearson, & Feder, 2009). Despite these differences, engineers and scientists share similar practices in reaching their goals (Bybee, 2011). The NGSS views these SEPs as conduits for students to simultaneously engage with and learn about science (Bybee, 2011; Osborne, 2014).

Demands of the NGSS

Shifts in instruction. Science instruction has been continuously changing at all levels. With the introduction of the NGSS (Achieve, Inc., 2013a) and its strong emphasis on teaching scientific practices and process skills, inquiry-based teaching practices will continue to be the gold standard for science curricular design and instruction. Inquiry-based teaching has been emphasized in science teaching and is part of the curricula of many countries (Achieve, Inc., 2013a; Swedish National Agency for Education, 2011). According to the U.S. Department of Education, the primary aim of science teaching is to prepare citizens who are internationally competitive, deal intelligently with science-related social issues, and influence policies related to impacts of science on society (DeBoer, 2000).

Yet, teaching science is different from teaching other content areas. A science teacher must possess strong PCK and excellent inquiry skills. Reform has outlined a change of vision for quality science education that affirms the need for teachers to acquire new types of knowledge and skills. The NGSS represents a new way of teaching and learning. Duschl (1985) stated, "If science education is to advance instruction beyond the rote memorization of information, which changes from decade-to-decade anyway, then methods of instruction, teacher training, and curriculum development different from those used in the past should be considered" (p. 555). Delivery of science instruction requires preparation of skills and highly qualified science classroom teachers. School districts must focus on developing teachers' content knowledge and PCK. To adequately meet the goals of the NGSS, teachers must weave topics and ideas together to show how they relate.

Cohesiveness during implementation. Implementing any new policy brings great challenges. One important goal of the NGSS is for students to build and apply ideas in a coherent manner. When policies relate to curriculum and instruction, teachers are at the heart of successful implementation. Teachers are policy implementers (Fowler, 2009). Anderson and Helms (2001) found that for teachers to implement practice-based reforms, they must have support and resources such as equipment, consumable supplies, and curriculum materials. Blumenfeld, Krajcik, Marx, and Soloway (1994) also found potential problems for teachers implementing new instructional methods, such as lack of resources and district curricular policy. District might also encounter an "implementation dip” as teachers encounter an innovation that requires new skills and new understandings (Fullan, 2001). Helping teachers to understand the vision and goals of the NGSS, including the SEPs, is an imperative first step to developing high quality curricular materials (Pruitt, 2014). These challenges could lead to a superficial implementation of the NGSS instead of what should be a deep change in pedagogy (Hopfenbeck, Flórez-Petour, & Tolo, 2015).

Need for highly quality curricular materials. There is a national urgency to identify the kind of instructional materials and related professional development that will best prepare teachers to meet the challenges of the NGSS. Successful implementation could require a considerable investment of resources to develop the appropriate materials and tools to support both the teacher and the student (Wilson, 2013). One approach is for districts to use their full curriculum program. Because the NGSS are so different from the NSES, districts have found that they are often unable to use their current science instructional materials for NGSS implementation (Achieve, Inc., 2013a). Many districts have not determined specific criteria for adopting, modifying, or creating the instructional materials; however, the key aspects of the NGSS to ensure high-quality instructional materials are contemporary themes of focus, rigor, and coherence. The focus of the materials should be on the core ideas in the NGSS: rigorous instructional materials should support all three dimensions to allow conceptual understanding, procedural skills, and application of the NGSS; coherent materials should provide a strong link between the three dimensions of the NGSS, with a progression between each unit, grade level, and grade span for a unified learning experience (Achieve, Inc., 2013a).

The focus of curriculum designers is shifting to support teachers' capacity to implement curricular materials. Ball and Cohen (1996) called for the design of curricular materials that would support teachers' learning as well as students' learning. In 2005, Davis and Krajcik built on Ball and Cohen's argument providing a set of design heuristics for curricular development. A curriculum is a tool for enacting and achieving the standards. Ball and Cohen (1996) suggested that the influence of curricular materials on teachers' practices could be increased if materials were "designed to place teachers in the center of curriculum construction and make teachers' learning central to efforts to improve education, without requiring heroic assumptions about each teacher's capacities as an original designer of curriculum" (p. 7). They went on to note that doing so "would require learning how to design and develop written materials as to be educative for teachers as well as students" (p. 8). The adoption of the new standards alone is insufficient to effect educational change, and engagement with a more open multifaceted process of implementation requires more than policy entrepreneurship.

Summary

The NGSS (Achieve, Inc., 2013a) and the NRC *Framework* (2012) are responses to the widespread use and consequences of fragmented knowledge and the memorization-based learning that past science standards embodied. Osborne (2014) acknowledged that science teachers will be working to make sense of the NGSS and the change it is asking teachers to take on in their own practice. The focus on teachers is critical because teachers are ultimately the agents of implementation for education reform (Sarason, 1996). Practitioners and researchers have become increasingly concerned with finding ways to support teachers in designing classroom instruction to meet the demands of the

NGSS (Pellegrino, 2013). Teachers must develop content knowledge and pedagogical skills not only in the three dimensions of the NGSS (practices, crosscutting concepts and disciplinary core ideas), but also in creating and enacting instruction that weaves together those dimensions.

CHAPTER 3

METHODS

This program evaluation incorporated a mixed-methods approach that used two data collection methods, one primarily qualitative and one primarily quantitative in design. Mixed-method designs may include a variety of approaches to collect data (Creswell, 2003). The use of multiple forms of data gave the study robust results. The evaluation questions guiding this study were:

1. In a selected large urban Maryland school district, what are middle school science teachers' perceptions regarding instructional practices that needed to be modified to align with the NGSS and SEPs?
2. To what degree do middle school science teachers' perceptions regarding instructional practices align with key practices of the NGSS and SEPs?
3. What instructional practices do science teachers use to meet the demands of the NGSS and SEPs?
4. To what degree do instructional practices science teachers use align with key aspects of the NGSS and SEPs?

Participants

The participants for this study were 12 science teachers: 10 women and two men from three urban middle schools. Study participants were African American and Filipino. Their years of teaching experiences ranged from 2-40 years. Seven teachers were certified in science; one teacher was certified in elementary and middle school; another teacher was certified in SPED; three were uncertified (Table 1). The 12 participants were all members of the science departments in three selected middle schools; they were recruited via email correspondence.

Table 1

Teacher Demographics

Teacher	Gender	Ethnicity	Years Teaching	Degree	Certification
1	Female	African American	30	MS + 60	K-12 Admin I
2	Female	African American	2	BS	7-12 Biology Life sciences
3	Female	African American	10	MBA	1-6 Middle
4	Female	African American	40	Ph.D.	SPED Middle & High (all content areas)
5	Female	African American	3	BS	None
6	Male	African American	10	Ph.D.	7-12 Biology
7	Female	Filipino	30	Double MS	7-12 Biology K-12 Admin I
8	Male	African American	2	MS	None
9	Female	African American	3	BS	None
10	Female	African American	26	Double MS	7-12 Biology
11	Female	African American	18	Ed.D.	SPED Early Childhood ESOL Middle Science
12	Female	African American	6	BS	Elementary 7-12 Chemistry

Data Sources

The program evaluation design included two data sources: semi-structured interviews and classroom observations. The focal point of this program evaluation was to collect both quantitative and qualitative data from middle school teachers identifying their understanding and practices regarding the pedagogical content knowledge (PCK) of SEPs for middle school students.

Interviews. I used a semi-structured interview protocol designed for this study (Appendix A) to collect data regarding teachers' demographic information and instructional practices while implementing SEPs in their classrooms. The themes utilized in this evaluation were derived from the NGSS SEPs and were crucial in developing the interview questions. The Table of Specification (Table 2) identifies the interview questions; content validity of the interview questions was achieved through charting this breakdown of the references from which questions were derived. The interview began with an open-ended question that led to discussion about teachers' classroom instruction. The semi-structured interview protocol contained a brief introduction to the task where I asked participants to describe the instructional practices used to teach the old science standards compared to the new standards. Interviews were conducted at the three school sites during the teachers' planning periods. Interviews were audiotaped to provide an accurate account of the discussion.

Table 2

Table of Specification

Interview Question	Associated Evaluation Question(s)	Related Research
1. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #1 Asking questions (for science) and defining problems (for engineering)?	1, 2	Pruitt, 2014; Rogan, 2007
2. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #2 Developing and using models?	1, 2	Achieve, Inc. 2013b; Allen & Penuel, 2014
3. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #3 Planning and carrying out investigations?	1, 2	Hattie, 2009; Marazano, Pickering, & Pollock, 2001
4. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #4 Analyzing and interpreting data?	1, 2	Garet et al., 2001; Spillane et al., 2006
5. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #5 Using mathematics and computational thinking?	1, 2, 3, 4	Pruitt, 2014; Rogan, 2007
6. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #6 Constructing explanations (for science) and designing solutions (for engineering)?	1, 2	Garet et al., 2001; Spillane et al., 2006
7. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #7 Engaging in argument from evidence?	1,2	Achieve, Inc. 2013b; Allen & Penuel, 2014
8. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #8 Obtaining, evaluating, and communicating information?	1, 2	Hattie, 2009; Marazano, Pickering & Pollock, 2001

Classroom observations. A researcher-designed observation protocol aligned to the NGSS SEPs was used to capture data (Appendix B). The observation protocol was adapted from the study district's classroom observation protocol, which is based on *The Framework for K-12 Science Education* and the NGSS; the observation protocol contains the eight SEPs, the subsections of each that describe the practices, and the progression of Grade 6-8 science competencies.

Data Collection

The study school district required the submission of an application to conduct educational research to the Department of Research and Evaluation (Appendix C). Once approved by the William & Mary Institutional Review Board, I contacted principals via email to ask permission to conduct research in their schools. Three principals gave their consent for me to conduct research. I then emailed the science teachers asking for their willingness to participate in the program evaluation. Each teacher who agreed to participate also received a follow up email containing a participant consent form and asking for times and dates of availability to conduct an interview. The interviews occurred in teacher's classrooms during their planning periods.

Interviews. An in-depth semi-structured interview with the participants was used to allow participants to reflect on instructional strategies and the SEPs. The individual interviews were one-on-one. Each interview lasted at least 30 minutes. Participants were informed that the interview was taped to capture their feedback accurately. Field notes were collected during the interview and classroom observations. Transcription occurred within a week of the interview. Audio recordings were deleted after transcription, member-checking, and data analysis. Data analysis was a triangulation of the interview, field notes and observation.

Classroom observations. Classroom observations were used to identify classroom instructional practices related to the NGSS SEPs. During a period of 10 weeks, 11 participating teachers were observed a minimum of three times. Scheduling time with Teacher 1 was challenging, as she was often unavailable; as a result, I only observed Teacher 1 twice. I scheduled classroom observations with teachers in advance. Each observation was for an entire class period, a time frame of at least 45 minutes. At times when teachers' lessons occurred over multiple days, I counted the multiple days as a single observation. I took notes on the observation protocol. The transcribed notes were used in addition to the classroom observation protocol to help analyze the final data.

Data Analysis

In this mixed-methods program evaluation, the evaluator's role was as a researcher-practitioner. The potential for researcher bias exists within any qualitative research based on previous life experiences and prior understandings (Patton, 2002). In this regard, my role as a science content expert in the school district created a background of knowledge and understanding that was used in the study but did not adversely influence data collection and analysis. While this experience and background could have influenced data interpretation, I reflected on my own beliefs and watched for biases during both data collection and data analysis phase.

Analysis of interview responses. The interviews were qualitative and required coding to identify commonalities and themes in the data collected. Data analysis required a systematic examination of all data using systematic coding of interview transcripts

(Rubin & Rubin, 2005). The analysis process was done in multiple steps. Responses were audio-recorded as well as documented on the interview protocol. The first step was to listen to the recorded interviews multiple times to ensure the accuracy of each statement transcribed. I transcribed the responses using word processing software. I then used a priori coding, applying pre-determined codes to segments of interview responses. The a prior codes were instruction, implementation and curriculum. Additionally, emergent codes were identified and applied as appropriate; emergent codes the need to unpack the standards, emphasis on lesson planning, and professional development needs.

Weber's (1990) procedure for developing an a priori coding framework begins by establishing categories based on theory. Categories are "a group of words with similar meaning or connotations" (Weber, 1990, p. 37). During this process, the raw data were formulated into meaningful statements; preliminary meaningful statements were then reexamined to uncover deeper levels of meaning (Ge, Lubin, & Zhang, 2010). In the next level of analysis, meaningful themes were clustered to help exam the relationships between and among them. Charts were used to help categorize and visualize the data. The strategy of member-checking was utilized to establish trustworthiness. Lincoln and Guba (1985) posit that member checking is a critical technique for establishing credibility in qualitative research. By involving participants in the data analysis process, new perspectives were revealed, and it allowed me to clarify any points that were unclear after data collection. There were times when the tape recording was unclear and I had to contact the participants via telephone or email to confirm inaudible segments of the interview. Feedback from participants was included in the final report. Participants informed me that the classroom observations did not paint a clear picture of all the SEPs they implement in their classrooms; the observation was limited to the 10-week scope of time.

Analysis of classroom observations. I conducted a comparative analysis of the classroom observation data related to which NGSS SEPs each teacher implemented; in addition, I calculated the total amount of time each teacher spent incorporating the eight practices. The classroom observation protocol allowed me to identify the instructional strategies and the NGSS SEPs that participants used most frequently. I entered the instructional strategies data into a Google spreadsheet that captured the SEPs to help further analyze and present the findings in tables and bar graphs (see Chapter 4). I also calculated how many SEPs teachers used in relation to the eight total SEPs. Table 3 summarize data analysis methods used for the study.

Table 3

Summary of Data Analysis Methods

Evaluation Question	Data Source	Analysis Methods
Q1. In a selected large urban Maryland school district, what are middle school science teachers' perceptions regarding instructional practices that needed to be modified to align with the NGSS and SEPs?	Interviews	Coding of data Generating categories and common themes
Q2. To what degree do middle school science teachers' perceptions regarding instructional practices align with key practices of the NGSS and SEPs?	Interviews	Coding of data Generating categories and common themes
Q3. What instructional practices do science teachers use to meet the demands of the NGSS and SEPs?	Classroom observations	Comparative analysis of observational data
Q4. To what degree do instructional practices science teachers use align with key aspects of the NGSS and SEPs?	Classroom observations	Comparative analysis of observational data

Note. NGSS = Next Generation Science Standards; SEP = Science and Engineering Practices

Delimitations, Limitations, Assumptions

Delimitations. This program evaluation involved 12 teachers from three urban middle schools in a selected school district in Maryland. Findings from this study cannot be generalized to other school settings. This study was delimited to the SEPs and did not address the other dimensions of the NGSS.

Limitations. The study was for a 10-week period during 2017-2018 school year. There was no random sampling. Participants were science teachers from three urban middle schools. Interview responses were based on teachers' perceptions.

Assumptions. I assumed that participants answered questions honestly and accurately. Another assumption was that the evaluator/researcher conducted observations and interviews that were unbiased. Further, I assumed that all participants were trained using the NGSS and that participants understood and were able to incorporate the SEPs in their classrooms.

Ethical Considerations

To ensure the safety and welfare of study participants, the study complied with the guidelines set forth by the College of William & Mary Institutional Review Board along with the research requirements in the selected school district. Before agreeing to participate in the study, I notified participants about the purpose of the study, the duration of the study, their privacy rights, methods for ensuring the confidentiality of data. All participants signed an informed consent document prior to participating in the study. I removed all personal identifiers from the data to protect the identity of participants in the study. All documents related to data collection were available to the participants. Additionally, participants read the final report.

CHAPTER 4

RESULTS

This program evaluation focused on 12 science teachers' perspectives and enactment of the NGSS SEPs in their classrooms. I used a mixed-methods design to incorporate both qualitative and quantitative data. Data from semi-structured interviews and classroom observations were collected over the course of 10 weeks during the 2017-2018 school year. In this chapter, the results of analyses answer the following evaluation questions:

1. In a selected large urban Maryland school district, what are middle school science teachers' perceptions regarding instructional practices that needed to be modified to align with the NGSS and SEPs?
2. To what degree do middle school science teachers' perceptions regarding instructional practices align with key practices of the NGSS and SEPs?
3. What instructional practices do science teachers use to meet the demands of the NGSS and SEPs?
4. To what degree do instructional practices science teachers use align with key aspects of the NGSS and SEPs?

As noted in Table 3, evaluation questions were answered using analysis of interview and classroom observation protocol data. A priori coding was used in this program evaluation. The major categories identified in the NGSS SEPs were instruction, implementation, and curriculum. Additionally, emergent codes were established by sorting through the data for themes, ideas, and categories for the purpose of making comparisons and drawing conclusions (Taylor & Gibbs, 2010).

Findings for Evaluation Question 1

In a selected large urban Maryland school district, what are middle school teacher's perceptions regarding instructional practices that needed to be modified to align with the NGSS and SEPs?

The 12 teachers who participated in this program evaluation provided insight into the practical processes involved in developing a culture of SEP implementation. Teachers displayed NGSS posters and SEPs in their classrooms and consistently referenced SEPs during instruction. Teachers' used the language of the NGSS during implementation to encourage students to change their dialogue and interactions. The teachers' perceptions were illuminated in the major categories and themes that developed during data analysis of the interviews. Table 4 displays the major categories and themes collected during the interviews along with the number of teachers who incorporated each theme.

Table 4

Major Categories and Themes

Major Category	Themes	Frequency
Instruction	• Connecting learning to real-world experiences • Transitioning from teacher-led instruction to student-centered learning • Incorporating inquiry activities that require students to learn science not to just do science • Visual representations of the NGSS and SEPs posted in the classroom • Providing opportunities for students to engage in authentic science	12/12
Implementation	• Lack of resources • Prior knowledge is the key to implementation • Using NGSS language on a daily basis • Integrate SEPs in every lesson; grade-level planning to share new strategies • Asking questions and defining problems • Building progression to help the students make sense of the standards	11/12*
Curriculum	• Textbook is not aligned to NGSS • District created curriculum aligned to NGSS • Use multiple resources such as scientific articles, trade books, Discovery Education, technology, and other resources recommended by NGSS and the National Science Teachers Association	12/12

*One teacher did not lesson plan with grade level due to other obligations.

Instruction. A shift in instruction is one of the key practices of the NGSS. Varied levels of implementation of the NGSS were prevalent among the teachers in this study; however, were limited teacher pedagogical changes due to inadequate professional training.

Implementation. Teachers in this study agreed that prior knowledge was a key factor in the implementation of the SEPs. All teachers referenced using NGSS language daily during implementation to change how their students communicate with one another. Teachers shared new strategies during collaboration, when time permitted.

Curriculum. Although the textbook was not aligned to the curriculum, all teachers reported using multiple resources that were aligned to NGSS. As noted in Chapter 1, quality curricular materials are required to implement the NGSS successfully. Some challenges for implementation that emerged from the interviews were time restraints, lack of resources, and the need for professional development. Teachers' also shared the complexities of the NGSS content, which they considered dense and not student friendly.

Findings for Evaluation Question 2

To what degree do middle school science teachers' perceptions regarding instructional practices align with key practices of the NGSS and SEPs?

Data derived from all 12 participants during the interview indicated that teachers had some understanding of the key practices of the NGSS SEPs, which are shifts in instruction, cohesive implementation, and using materials aligned to the curriculum. Table 5 displays the key practices used by the teachers.

Table 5

Key Practices of the NGSS SEPs

Key Practice	% Teachers Aligning Instruction
Shifts in Instruction	92%
Cohesive Implementation	100%
Quality Curriculum	100%

Although teachers did not agree that a shift of instruction was needed to implement the SEPs, they all agreed that cohesive implementation and quality curricular materials are needed to fully implement the SEPs successfully.

During the interview, one teacher shared the following regarding her implementation of SEP 1, *Asking questions and defining problems*, “asking questions and defining problems are essential and key practices of the NGSS this initial step helps to set up the proper framework that aligns with the key practices of the NGSS.” The teacher indicated that all of the standards are essential and correlate to the original rules of the scientific method; therefore, no modification is needed. Teacher 9 noted that modifications vary from class to class and student to student. Other teachers discussed building progression and providing support to build students’ understanding of each SEP. Each teacher indicated background knowledge and incorporating relevant issues students can relate to were key components to implementing the SEPs effectively.

When asked about SEP 2, *Developing Models*, the teachers pointed to or discussed lessons on models that their students developed. For example, Teacher 4 brought in models of fossils for the students to see and then provided a lesson which required them to conduct research on fossils and to participate in a design-based activity that create fossils. Teacher 3 complained about the overload the eighth-grade curriculum has on developing models; she allows her students to choose the type of model they want to create: 3D, Google drawings, and PowerPoints. Teacher 3 also expressed the need for professional development in model instruction. Teacher 12 introduced SEP by asking students, “What is a model?” Initially, there were a lot of barriers and misconceptions of what a model was. Teacher 9 worked with low-achieving students and her plans to develop models usually resulted in teacher demonstrations; however, her high-achieving classes worked in small groups and built wind turbines. Teacher 2 taught students in the gifted program. She assigned her students an engineering project to construct a functioning microscope or overhead projector out of natural resources. The students were required to design and document each step of the engineering process. The context of the lesson provided an opportunity for students to utilize multiple SEPs during the construction of the microscope and the overhead projector.

Each teacher emphasized that prior knowledge determined how he or she modified instruction to meet the needs of SEP 3, *Planning and Carrying Out Investigations*. The goal of implementation was to go from teacher-led instruction to student-led collaboration; however, a few teachers faced challenges with totally letting go of prescriptive teaching due to class dynamics. One teacher used simulation videos and teacher demonstrations when implementing SEP 3. Another teacher grouped students by ability levels, strongest to struggling: "The strongest student understood the investigation and, therefore, served as the group leader to facilitate the process. The middle level student was the materials handler and timekeeper and the struggling student always did the hands-on activity." The remaining seven teachers introduced the phenomena within the curriculum; students were then given the opportunity to construct their own understanding by searching their way forward to find solutions to a problem through multifaceted tasks.

SEP 4, *Analyzing and Interpreting Data*, was a practice all teachers agreed needed to be implemented more. One teacher had students develop a birth to present timeline, showing how data can be used in everyday life; each date emphasized a milestone in the student's life. Another teacher had students analyze the data from their pre-assessments and post-assessments to measure growth. One of the 12 teachers described herself as being data-driven. She incorporated data in lessons at least three times a week by using graphs, tables, and coding. Her students often asked her, "Are you a science teacher or a math teacher?"

While implementing SEP 5, *Using Mathematics and Computational Thinking*, each teacher designed lessons and investigations to include the use of math. The eighth-grade teachers mentioned balancing chemical equations. Their students not only used numbers to balance equations, they had to understand subscripts and the reasoning for using specific numbers to balance the equation. Teacher 12 shared an investigation that required the use of one drop of a substance and some students used more than one drop. This was a teachable moment because the extra drops changed the outcome of the investigation. Students then realized the importance of using accurate measurements. Teacher 5 explained that although her students use mathematics, they did not always know how to use computational thinking. She shared, "My geometry students used mathematical representation when constructing their models, [but] no other students incorporated the use of math." Teacher 4 found SEP 5 challenging but indicated incorporating everyday life worked best; she provided the example of teaching students about cooking measurements. Teacher 9 said she struggled with SEP 5 because "we are so concept heavy. I only teach lower [achieving] students and I haven't reached the point of teaching computational thinking when reading charts and graphs is foreign to them."

SEP 6, *Constructing Explanations and Designing Investigations*, required in-depth planning for all of the teachers in this study. Background knowledge was the prerequisite for implementing this SEP. Rather than giving the students recipe lab activities describing each step of the process, teachers used inquiry activities. Students were given a topic and materials and directed to design an investigation. One teacher shared how her students had to build a series circuit. The teacher provided materials but gave no directions. The inquiry activity allowed students to develop critical thinking skills and creativity as well as problem solve, thus involving them in their own learning.

Engaging in Argument from Evidence, SEP 7, also required in-depth planning for all teachers in this study. The common response in their explanation was Claim, Evidence, and Reasoning, also known as CERs. CERs are challenging as students lack the ability to construct logical explanations by connecting reasoning to the evidence. Teachers in the study shared that most students used personal feelings rather than relying on evidence. Teacher 9 used Socratic seminars to teach SEP 7. Her students had to explain a claim by citing the evidence. Other teachers used scientific articles and cooperative and collaborative groups to tie in literacy utilizing persuasive arguments. The district promotes literacy across all content areas, so teachers found that SEP 7 tied into the district's literacy plan.

When modifying instruction to implement SEP 8, *Obtaining, Evaluating, and Communicating Information*, teachers incorporated innovative approaches. One teacher introduced the concept of obtaining information by asking a question, "How do we know if information is valid?" Another teacher embraced the use of collaborative learning where each group member had an active role in the project. A third teacher provided a rubric as a guide during initial implementation. Teacher 4 assigned a project that required students to create a solar home. The students had to conduct background research on solar energy, design the house, obtain the materials to build a solar energy house, use a rubric to evaluate the process, and present the information and finished project to their peers. One teacher used gallery walks and world cafés where the students researched a topic and presented their ideas on a poster; while group members circulated the room to visit other posters, one group member stayed at the poster to answer questions from peers.

Findings for Evaluation Question 3

What instructional practices do science teachers use to meet the demands of the NGSS and SEPs?

Unlike prior science standards, which limited opportunities for students to learn science, the NGSS demands that students engage in authentic science by making sense of the context. The NGSS also accounts for students' prior knowledge. The 12 teachers' primary focus during implementation was connecting the students' prior knowledge to the current topic. Not only did they provide opportunities for students through inquiry-based lessons, they also showed students how to use simple everyday materials to engage in science. Although some teachers faced challenges during implementation, most integrated SEPs in their design of inquiry investigations to make their instruction more effective. Table 6 displays the multiple instructional strategies teachers in this study used to implement the SEPs.

Table 6

Instructional Strategies used to Implement the SEPs

Strategy	% Teachers Using Strategy
Discussions	50%
Asking questions	100%
Direct instruction	17%
Design-based project	33%
Teacher demonstrations	16%
Project-based learning	83%
Inquiry-based activities	100%
Think-Pair-Share	67%
Socratic Seminars	8%
Videos	100%
Lab simulations	17%
Gallery walks/World café	33%
Cooperative learning	83%
Collaborative group	100%
Link content to real world	100%
Use student assessment rubrics	67%

Findings for Question 4

To what degree do instructional practices science teachers use align with key aspects of the NGSS and SEPs?

Based on analysis of data from 39 classroom observations, there was an adequate level of endorsement of the NGSS SEPs among the teachers (see Tables 7-14). The average frequency of SEP implementation was based on the number of times I observed each SEP, divided by the total number of observations I conducted. I observed each teacher two to four times.

Table 7 shows the average percentage of implementation of SEP 1, *Asking Questions and Defining Problems*, by teacher. All 12 participants implemented at least one subsection of SEP 1.

Table 7

Average Percentages of Implementation of SEP 1: Asking Questions and Defining Problems, by Teacher

Practice	**Teacher**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
P1.1	50%	100%	25%	50%	0%	100%	100%	25%	67%	33%	33%	33%
P1.2	0%	0%	25%	25%	0%	0%	50%	25%	67%	0%	0%	33%
P1.3	50%	100%	25%	0%	0%	67%	75%	0%	67%	33%	0%	33%
P1.4	0%	67%	0%	25%	0%	67%	75%	0%	100%	33%	0%	33%
P1.5	50%	67%	25%	25%	33%	33%	0%	25%	67%	0%	33%	33%

Note. Average percentages are based on the number of times the SEP was observed, divided by the total number of classroom observations. For example, I observed Teacher 1 twice; I observed P1.1 on 1 of 2 observations, which equals 50%. Teacher 1 was observed twice; Teachers 2, 5, 6, 9, 10, 11, and 12 were observed three times each; Teachers 3, 4, 7, and 8 were observed four times each.

Table 8 shows the average percentage of implementation of SEP 2, *Developing Models*. Eleven out of 12 teachers implemented at least one subsection of SEP 2. Teacher 12 did not implement SEP 2.

Table 8

Average Implementation of SEP 2: Developing Models, by Teacher

Practice	**Teacher**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
P2.1	50%	33%	0%	75%	33%	33%	50%	50%	0%	33%	33%	0%
P2.2	50%	33%	50%	75%	33%	33%	50%	50%	0%	33%	33%	0%
P2.3	0%	0%	0%	75%	33%	0%	25%	25%	0%	33%	67%	0%
P2.4	50%	33%	50%	50%	33%	33%	50%	100%	67%	67%	67%	0%
P2.5	50%	67%	50%	50%	33%	33%	50%	75%	33%	100%	67%	0%
P2.6	0%	33%	50%	75%	33%	0%	0%	50%	33%	100%	67%	0%

Note. Average percentages are based on the number of times the SEP was observed, divided by the total number of classroom observations. For example, I observed Teacher 1 twice; I observed P2.1 on 1 out of 2 observations, which equals 50%. Teacher 1 was observed twice; Teachers 2, 5, 6, 9, 10, 11, and 12 were observed three times each; Teachers 3, 4, 7, and 8 were observed four times.

Table 9 shows the average implementation of SEP 3, *Planning and Carrying Out Investigations*, by teacher. Ten out of 12 teachers implemented at least one subsection of SEP 3. Teacher 11 and Teacher 12 did not implement SEP 3.

Table 9

Average Implementation of SEP 3: Planning and Carrying Out Investigations, by Teacher

Practice	**Teacher**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
P3.1	0%	33%	0%	25%	0%	0%	0%	25%	0%	67%	0%	0%
P3.2	50%	0%	25%	50%	67%	67%	25%	50%	67%	100%	0%	0%
P3.3	0%	0%	0%	0%	0%	0%	0%	0%	33%	33%	0%	0%
P3.4	0%	0%	0%	25%	67%	0%	25%	25%	33%	67%	0%	0%
P3.5	0%	33%	25%	50%	33%	0%	0%	50%	33%	67%	0%	0%

Note. Average percentages are based on the number of times the SEP was observed, divided by the total number of classroom observations. For example, I observed Teacher 1 twice; I observed P3.2 on 1 out of 2 observations, which equals 50%. Teacher 1 was observed twice; Teachers 2, 5, 6, 9, 10, 11, and 12 were observed three times each; Teachers 3, 4, 7, and 8 were observed four times each.

Table 10 shows the average implementation of SEP 4, *Analyzing and Interpreting Data*, by teacher. Five out of 12 teachers implemented at least one subsection of SEP 4. Teachers 1, 2, 4, 6, 7, 8, and 11 did not implement SEP 4.

Table 10

Average Implementation of SEP 4: Analyzing and Interpreting Data, by Teacher

Practice	**Teacher**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
P4.1	0%	0%	50%	0%	33%	0%	0%	0%	33%	0%	0%	33%
P4.2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
P4.3	0%	0%	25%	0%	33%	0%	0%	0%	0%	33%	0%	0%
P4.4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
P4.5	0%	0%	0%	0%	33%	0%	0%	0%	0%	33%	0%	0%
P4.6	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%

Note. Average percentages are based on the number of times the SEP was observed, divided by the total number of classroom observations. For example, I observed Teacher 3 four times; I observed P4.1 on 2 out of 4 observations, which equals 50%. Teacher 1 was observed twice; Teachers 2, 5, 6, 9, 10, 11, and 12 were observed three times each; Teachers 3, 4, 7, and 8 were observed four times each.

Table 11 shows the average implementation of SEP 5, *Using Mathematics and Computational Thinking*, by teacher. Nine out of 12 teachers implemented at least one subsection of SEP 5. Teacher 1, Teacher 7, and Teacher 12 did not implement SEP 5.

Table 11

Average Implementation of SEP 5: Using Mathematics and Computational Thinking, by Teacher

Practice	**Teacher**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
P5.1	0%	0%	50%	0%	0%	0%	0%	0%	33%	0%	0%	0%
P5.2	0%	33%	25%	100%	33%	67%	0%	75%	67%	67%	33%	0%
P5.3	0%	33%	0%	100%	0%	67%	0%	75%	0%	67%	33%	0%
P5.4	0%	33%	0%	25%	0%	0%	0%	25%	33%	0%	0%	0%

Note. Average percentage based on the number of times the SEP was observed, divided by the total number of classroom observations. For example, I observed Teacher 2 three times; I observed P5.2 on 1 out of 3 observations, which equals 33%. Teacher 1 was observed twice; Teachers 2, 5, 6, 9, 10, 11, and 12 were observed three times each; Teachers 3, 4, 7, and 8 were observed four times each.

Table 12 shows the average implementation of SEP 6, *Constructing Explanations and Designing Investigations*, by teacher. All 12 teachers implemented at least 4 subsections of SEP 6.

Table 12

Average Implementation of SEP 6: Constructing Explanations and Designing Investigations, by Teacher

Practice	Teacher											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
P6.1	50%	67%	100%	75%	100%	33%	75%	50%	33%	33%	67%	67%
P6.2	0%	67%	75%	75%	67%	33%	75%	75%	67%	33%	100%	0%
P6.3	100%	100%	100%	0%	100%	100%	100%	75%	100%	33%	100%	67%
P6.4	50%	67%	25%	50%	100%	67%	100%	50%	100%	33%	33%	67%
P6.5	50%	67%	0%	25%	33%	0%	0%	25%	0%	33%	33%	33%
P6.6	0%	33%	0%	25%	33%	0%	0%	25%	0%	33%	33%	0%

Note. Average percentages are based on the number of times the SEP was observed, divided by the total number of classroom observations. I observed Teacher 1 twice; I observed P6.1 on 1 out of 2 observations, which equals 50%. Teacher 1 was observed twice. Teachers 2, 5, 6, 9, 10, 11, and 12 were observed three times each; Teachers 3, 4, 7, and 8 were observed four times each.

Table 13 shows the average implementation of SEP 7, *Engaging in Argument from Evidence*, by teacher. Eight out of 12 teachers implemented at least one subsection of SEP 7. Teachers 1, 2, 10, and 12 did not implement SEP 7.

Table 13

Average Implementation of SEP 7: Engaging in Argument from Evidence, by Teacher

Practice	**Teacher**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
P7.1	0%	0%	0%	0%	33%	33%	25%	0%	67%	0%	33%	0%
P7.2	0%	0%	25%	0%	0%	0%	25%	0%	100%	0%	0%	0%
P7.3	0%	0%	25%	50%	0%	67%	25%	50%	100%	0%	0%	0%
P7.4	0%	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%
P7.5	0%	0%	0%	50%	0%	0%	0%	50%	0%	0%	0%	0%

Note. Average percentage based on the number of times the SEP was observed, divided by the total number of classroom observations. For example, I observed Teacher 3 four times; I observed P7.2 on 1 out of 4 observations, which equals 25%. Teacher 1 was observed twice; Teachers 2, 5, 6, 9, 10, 11, and 12 were observed three times; Teachers 3, 4, 7, and 8 were observed four times.

Table 14 shows the average implementation of SEP 8, *Obtaining, Evaluating, and Communicating Information*, by teacher. All 12 teachers implemented at least one subsection of SEP 8.

Table 14

Average Implementation of SEP 8: Obtaining, Evaluating, and Communicating Information, by Teacher

Practice	**Teacher**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
P8.1	50%	33%	75%	0%	33%	0%	50%	0%	33%	33%	67%	100%
P8.2	0%	33%	75%	0%	33%	0%	25%	0%	33%	33%	33%	67%
P8.3	0%	0%	75%	0%	0%	0%	25%	0%	33%	0%	0%	67%
P8.4	0%	0%	0%	0%	33%	0%	0%	0%	67%	0%	0%	33%
P8.5	0%	33%	75%	75%	33%	100%	100%	75%	100%	33%	67%	100%

Note. Average percentage based on the number of times the SEP was observed, divided by the total number of classroom observations. For example, I observed Teacher 1 twice; I observed P8.1 on 1 out of 2 observations, which equal 50%. Teacher 1 was observed twice; Teachers 2, 5, 6, 9, 10, 11, and 12 were observed three times; Teachers 3, 4, 7, and 8 were observed four times.

Teachers integrated SEP components into instruction at varying levels. The lowest level of usage was within SEP 4, *Analyzing and Interpreting Data*; the greatest usage was within SEP 6, *Constructing Explanations and Designing Investigations*. All teachers in the study implemented SEP 1, *Asking Questions and Defining Problems*; SEP 3, *Planning and Carrying Out Investigations*; SEP 6, *Constructing Explanations and Designing Investigations*; and SEP 8, *Obtaining, Evaluating and Communicating Information*. All teachers except Teacher 12 implemented SEP 2, *Developing Models*. Implementation of other SEPs was less consistent: nine teachers implemented SEP 5, *Using Mathematics and Computational Thinking*; eight implemented SEP 7, *Engaging in Argument from Evidence*. Only five teachers implemented SEP 4, *Analyzing and Interpreting Data*; however, no teachers implemented SEP 4 subsections 4.2 (Distinguish between casual and correlational relationship data) or 4.4 (Apply concepts of statistics and probability including mean, median, mode, and variability to analyze and characterize data, using digital tools when feasible). Interestingly, all participants except Teacher 1 implemented SEP 8.5 (Communicate scientific and/or technical information in writing and/or oral presentations).

Figures 3 through 11 show the overall frequency of all 12 participants' observed implementation of SEP subsections 1.1 through SEP subsections 8.5 out of 39 observations. The lowest observed frequencies of implementation were SEP 4.2 *Distinguish between causal and correlational relationships in data* and SEP 4.4 *Apply concepts of statistics and probability including mean, median, move and variability to analyze and characterize data, using digital tools and methods,* which were not observed. Other low-frequency subsections included SEP 4.6 *Analyze data to define an optimal* *operational range for proposed object, tool, process or system that best meets criteria success* and SEP 7.4 *Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints*, which were each observed only once across all observations and SEP 3.3 *Evaluate the accuracy of various methods for collecting data* and SEP 4.5 *Consider limitations of data analysis (e.g. measurement error) and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g. multiple trials)* , which were each observed only twice across all observations. The highest frequencies of implementations were SEP 6.3 *Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use and explanation for real-world phenomena, examples or events*, which I observed 31 times; SEP 8.5 *Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations*, which I observed 27 times; SEP 6.1 *Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena*, which I observed 25 times; SEP 6.4 *Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion*, which I observed 24 times; and SEP 6.2 *Construct a scientific explanation using models or representations based on valid and reliable evidence obtained from sources* (including the students' own experiments) *and the assumption that theories and law that describe the natural world operate today as the did in the past and will continue to do so in the future*, which I observed 23 times.

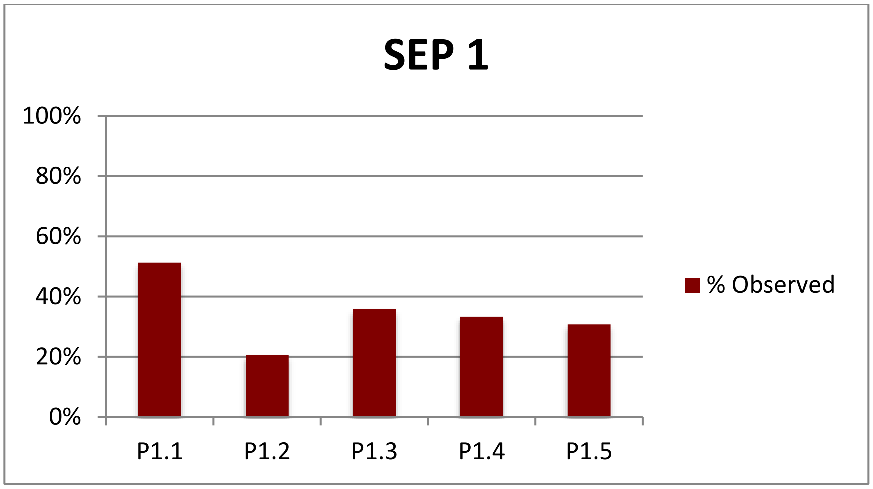

Figure 3. Observed frequencies of implementation of SEP 1: Asking Questions and Defining Problems.

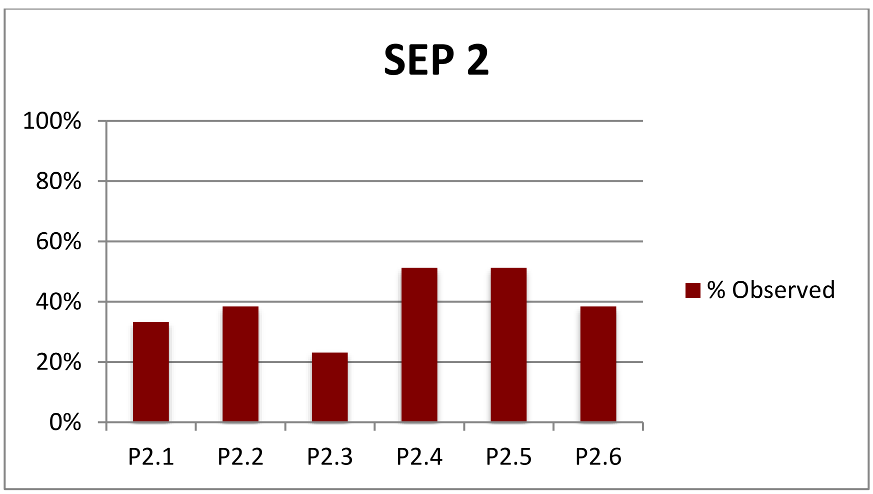

Figure 4. Observed frequencies of implementation of SEP 2: Developing Models.

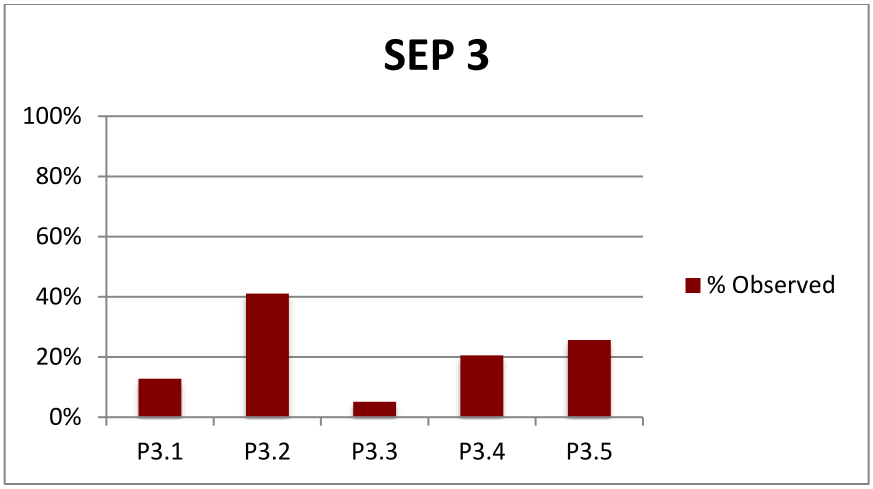

Figure 5. Observed implementation of SEP 3: Planning and Carrying Out Investigations.

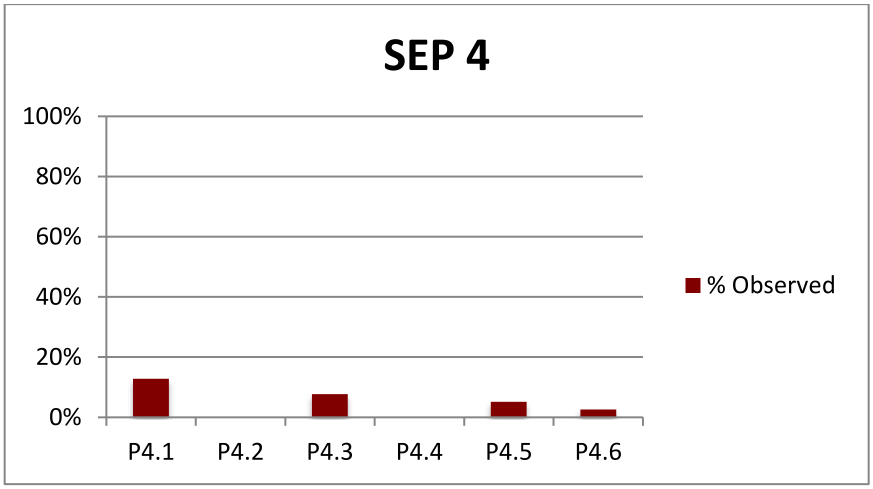

Figure 6. Observed frequencies of implementation of SEP 4: Analyzing and Interpreting Data.

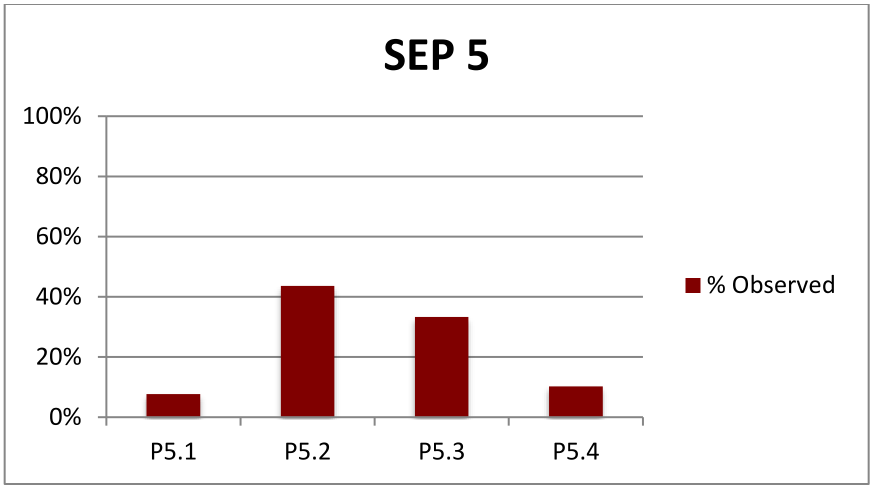

Figure 7. Observed frequencies of implementation of SEP 5: Using Mathematics and Computational Thinking.

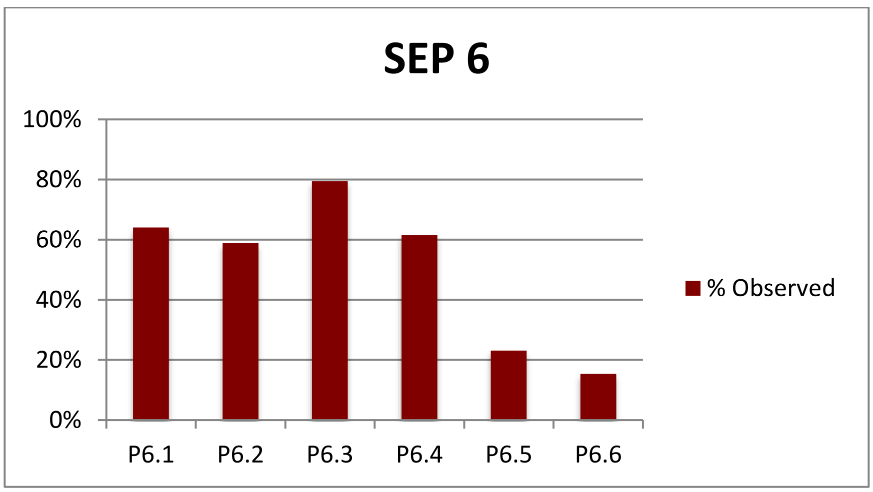

Figure 8. Observed frequencies of implementation of SEP 6: Constructing Explanations and Designing Investigations

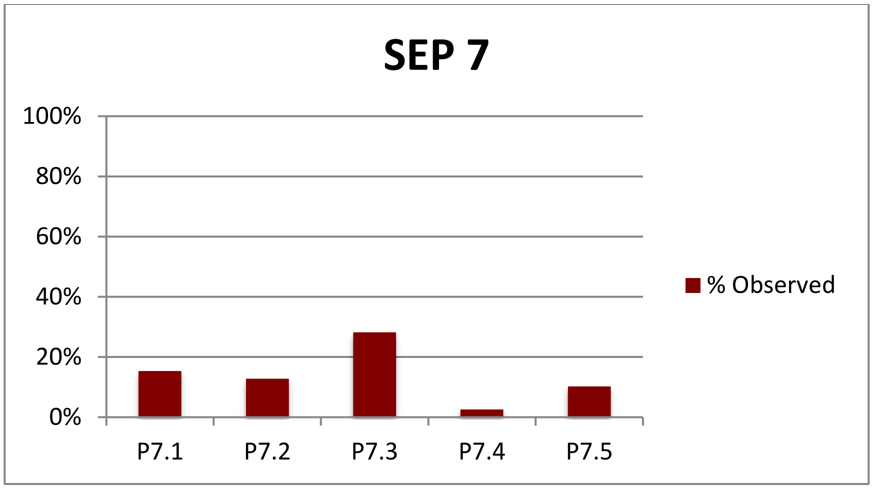

Figure 9. Observed frequencies of implementation of SEP 7: Engaging in Argument from Evidence.

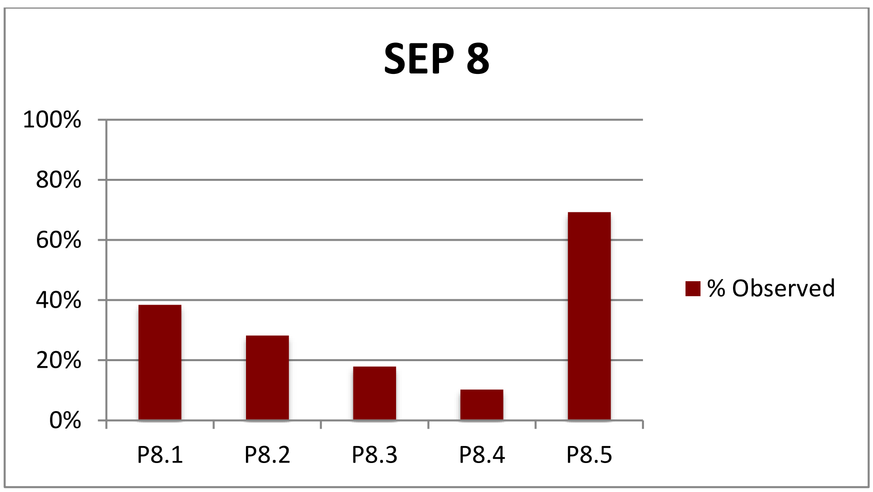

Figure 10. Observed frequencies of implementation of SEP 8: Obtaining, Evaluating, and Communicating Information.

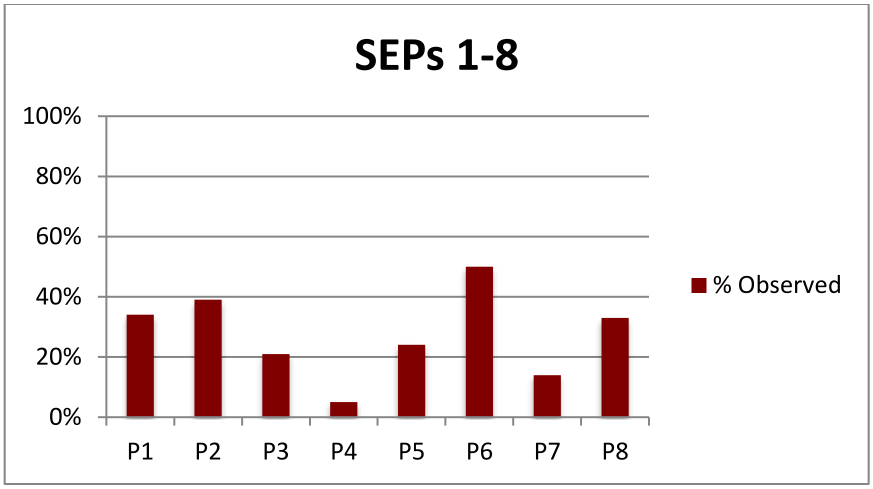

Figure 11. Overall observed frequencies of implementation of SEPs 1-8.

Figure 11 shows the overall observed frequencies of SEPs 1-8 implementation by all participants. The lowest observed frequency of implementation was SEP 4 (Analyzing and Interpreting Data), for a total of 5% (2 out of the total 39 observations); the highest observed frequency of implementation was SEP 6 (Constructing Explanations and Designing Investigations), for a total of 50% (20 out of the total 39 observations).

CHAPTER 5

DISCUSSION

In this study, I investigated 12 middle school science teachers' perceptions of the Next Generation Science Standards (NGSS) Science and Engineering Practices (SEPs) as well as the shifts in instructional practices that are necessary to enact the new standards in their classrooms. Four evaluation questions focusing on the implementation of the NGSS SEPs guided this mixed-methods study. The results of the analysis addressing these questions are discussed below. As noted in Chapter 1, the NGSS and the accompanying *Framework for K-12 Science Education* significantly shifts science teaching and learning; however, the reform documents do not describe how teachers are to change their instruction when implementing the new standards. I hope the findings of this study will inform the district, state, and other stakeholders in their efforts to implement the NGSS effectively. The following discussion provides a summary of findings related to each of the research questions that guided the study.

Evaluation Question One

In a selected large urban Maryland school district, what are middle school science teachers' perceptions regarding instructional practices that needed to be modified to align with the NGSS SEPs?

The eight semi-structured interview questions were designed to answer this question; each question was directly related to a different SEP. As presented in Chapter 4, three major categories where identified in this study: instruction, implementation, and curriculum, as well as several emergent themes, such as the need to unpack the standards, emphasis on lesson planning, and professional development needs.

Instruction. Overall, teachers in this study indicated extensive integration of the NGSS SEPs during instruction. Eleven of the 12 participants reported modifying instruction to align with the NGSS SEPs. The one teacher who did not modify instruction indicated that the scientific method and the use of inquiry already had the NGSS SEPs embedded. She said, “SI already do this, the focus now is on the science and engineering practices.” Although all of the teachers in this study incorporated inquiry-based activities during instruction with the prior science standards, the use of inquiry changed from structured inquiry and teacher-directed pedagogy to an open inquiry design, which is more student-centered. The most common component to all 12 participants’ modification was making real-world connections during instruction. Another factor identified in modification was the teacher as the facilitator and the student leading their learning.

All of the teachers in this study agreed that the NGSS SEPs required a shift in teaching and learning. Teachers reported that this transition required teaching students how to learn. One teacher said,

> Before switching roles in the classroom, I ask myself, “What do I need them to know? What is the expected outcome? How do I get my students to realize that there may be more than one solution to a problem? and How do I guide them without telling them?”

The most common aspect of instruction for these 12 participants was to provide opportunities for students to engage in authentic science: having students generate their own questions, develop their own problems, and seek solutions. The NGSS demands that students take responsibility for their own learning experiences, participating in the SEPs to learn science content (Bybee, 2011). Previous researchers have suggested that meaningful participation where students revise their own arguments in order to resolve discrepancies and inconsistences gave students more responsibility for their own learning (Berland & Reiser, 2009). These findings are consistent with the classical writing of Dewey (1910), who emphasized a more student-centered approach to science instruction and the need for students to engage in real-world science experiences and challenges.

Implementation. All 12 participants reported prior knowledge being the key to implementation, for both teachers and students. This is consistent with previous research that demonstrates the importance of incorporating student experiences and prior knowledge into the classroom (Barton, 2002; Lee, Luykx, Buxton, & Shaver, 2007). The NGSS SEPs are not one-size-fits-all standards. Each class is different as well as each student's experiences. Teachers will need ongoing professional development not only to learn the pedagogical content but also to differentiate their instruction. As stated in Chapter 1, Perkins and Reese (2014) determined that effective implementation of the reform strategies framed within the NGSS required enhancing both content and pedagogical content knowledge (PCK).

Perhaps because none of the teachers in this study had an engineering background, they all agreed that collaborating with colleagues and reflecting after implementation helped to make sense of the NGSS SEPs. During the implementation phase, reflection supports the development of engineering fluency by encouraging teachers to try new components of the process, reflect on the outcomes, and move on to new focal points (Cunningham & Carlsen, 2014). Other researchers (Heng & Khim, 2004; Hung, 2008; McAlphine & Weston, 2000; Reid & Horváthová, 2016) have suggested that conscious reflection fosters professional growth.

Several impediments to implementation emerged during the interviews: lack of resources to accomplish a planned task; the need for more time for instruction, collaboration, and time to make sense of the standards due to the complexity of the NGSS; and the difficulty of the pedagogical changes that required additional planning. These findings are supported by extensive research on implementing new reforms (Fullan, 2010; Trygstad, Smith, Banilower, & Nelson, 2013).

Curriculum. All participants reported that the textbook was not a primary resource and lacked alignment to the NGSS. Teachers became more aware of the resources they used as a result of this finding. To meet the needs of the NGSS SEPs, multiple resources were used, including (but not limited to): Discovery Education, trade books, scientific articles, technology, and resources recommended by NGSS and the National Science Teachers Association (NSTA). This finding was consistent with educative curriculum materials being powerful tools in supporting teachers' implementation (Ball & Cohen, 1996, Davis & Krajcik, 2005; Remillard, 2005). Given the many challenges of developing such materials, it could be years before high-quality materials that make the NGSS vision a reality are available. In the meantime, the district uses the Educators Evaluating the Quality of Instructional Products (EQUiP) Rubric (Achieve, Inc., 2014) to identify the characteristics of materials that are well aligned to NGSS and support achievement goals through high-quality instruction and assessment.

Emergent themes. In addition to a priori codes, several other themes emerged that provided valuable insight into the teachers' experiences: the need to unpack the standards, emphasis on lesson planning, and professional development needs. Each teacher expressed the need to unpack and decipher the standards prior to designing a lesson. Prior to teaching the lesson, the teachers had to unpack and decipher the standards with the students; the process clarified misconceptions and interpretations. The teachers indicated the standards were complex and the depth of the content was daunting. Teachers must understand the standards (Pruitt, 2014) as well as the students. The second emergent theme was lesson planning. Unlike prior NSES lessons that were guided by an objective, the NGSS provide a set of performance expectations that specify learning outcomes (NRC, 2012). The performance expectations embody the SEPs, crosscutting concepts, and the disciplinary core ideas. Due to the complexities of the NGSS, the teachers had to translate the performance expectations into an instructional sequence (e.g., Bybee, 2013); before they developed lessons and activities. The process required a lot of planning time. The third emergent theme was the need for professional development. All teachers indicated the need for ongoing professional development. The teachers also revealed that they had limited training on the NGSS, attending only one or two district professional development sessions. The majority of their knowledge of the NGSS came from collaboration with colleagues, websites, and NGSS publications. Research indicated that effective professional development led to increased content knowledge (Farmer, Klein-Gardner, & Reimer, 2015; Guskey, 2003). The teachers emphasized how important professional development was to increase their PCK to meet the demands and the visions of the NGSS and SEPs.

Evaluation Question Two

To what degree do middle school science teachers' perceptions regarding instructional practices align with key practices of the NGSS and SEPs?

As mentioned previously, all stakeholders in education must embrace a paradigm shift that adopts reformed science teaching practices. The data collected from the interviews indicated the teachers in this study perceived changes were warranted in teaching the NGSS SEPs. The major shift in instruction was the teacher as the facilitator and the student taking a more autonomous role in learning science. The adoption of the NGSS poses a challenge to teachers to shift their instruction from teaching science as isolated facts to teaching science as a practice (Krajcik, Codere, Dahsah, Bayer, & Mun, 2014; NSTA, 2016). To meet the demands of the NGSS teachers have to shift their instruction. The NGSS require more independence from students compared to previous science standards (Bybee, 2014). Although most of the teachers' perceptions were positive about the NGSS SEPs, they realized they lacked adequate training, resources, and time to implement the standards effectively.

Evaluation Question Three

What instructional practices do science teachers use to meet the demands of the NGSS and SEPs?

One purpose of the NGSS is to provide students with an authentic science education by integrating the use of inquiry within each standard. There were 16 instructional strategies that the 12 participants used during the classroom observations to implement the SEPs in their classrooms (see Table 5 in Chapter 4). Overall, 14 of the 16 instructional strategies used embodied the key aspect of the NGSS SEPs; the two exceptions were direct instruction and teacher demonstration, which were more teacher-directed than student-centered. The most commonly observed instructional strategies across all participants were *asking questions*, *inquiry-based activities*, *videos*, *collaborative groups*, and *linking content to the real world*. NGSS SEPs integrate authentic learning experiences. An example was the fossil lesson taught by several of the eighth-grade teachers. The students were asked an initial question “What are fossils?” During the class discussion, several other questions emerged and students then worked collaboratively to answer the questions and provide evidence. Next, a video was shown on fossil formation. Finally, students developed a model of a fossil. By exploring the concept, students were able to investigate and research fossils with peers and then share their understanding by creating a model. The sequential steps the eighth-grade teachers used with their fossil lesson were consistent with earlier research related to the Karplus Learning Cycle (Karplus, 1977) and the Model Cycle (Hestenes, 1987). These modeling cycles include a three-phase process: (a) model construction, (b) model validation, and (c) deployment. Models are tools that students develop to make sense of the physical reality. Previous researchers influenced the conceptualization of modeling articulated in NGSS (Schwarz et al., 2009; Windschitl, Thompson, & Braaten, 2008). The NGSS SEPS support a better understanding of how scientific knowledge is produced and how engineering solutions are developed (NRC, 2012).

Evaluation Question Four

To what degree do instructional practices science teachers use align with key aspects of the NGSS and SEPs?

Analysis of observation data revealed that teachers in this study implemented all eight SEPs throughout the 39 observations at varying degrees. SEP 6, *Constructing*

Explanations and Designing Investigations, was the most frequently observed practice; SEP 4, *Analyzing and Interpreting Data*, was the least frequently observed practice. This investigation also identified SEP subsections that teachers implemented less frequently. Recall from previous discussion that teachers must have not only scientific knowledge of the NGSS SEPs, but also the ability to teach the NGSS SEPs to students. As presented by Shulman (1986, 2015), the development of PCK entailed a deep knowledge of the connection between and integration of subject matter knowledge, pedagogical competency, and real-world practice. The low-level of implementation of specific NGSS SEPs indicated that there is an ongoing need for professional development to train teachers on how to develop instructional strategies to implement those low competencies. The low level of implementation of specific NGSS SEPs may also be the result of class dynamics; teachers who taught struggling learners indicated that some SEPs were a challenge to implement. The high-level implementation of specific NGSS SEPs reflects teachers' relatively high levels of competencies in those areas. Although all NGSS SEPs were implemented, teachers need to understand the multiple components to fully meet the demands of the NGSS SEPs. A teacher's knowledge and competencies play a role in students' achievement (Leong, Meng, & Rahim, 2015). As noted in Chapter 2, teachers need to have a PCK base that enables them to make content understandable to their students (Shulman, 1986).

Discussion of the Findings

The findings of this study are the first step to understanding how science teachers implement the NGSS SEPs. Several innovations for NGSS SEPs are worth noting. The teacher-centered approach was replaced with the student-centered approach. As stated above**,** Dewey (1910) emphasized a more student-centered approach to science instruction and the need for students to engage in real-world science experiences and challenges. Bybee (2014) indicated that the NGSS requires more independence from students. Each teacher in this study emphasized the use of real-world connections throughout her lessons. As researchers have suggested, students' science learning will be most successful if classroom experiences draw on and connect with their personal experiences (Rosebery, Ogonowski, DiSchino, & Warren, 2010; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

Teachers in this study were often faced with challenges to implement the NGSS SEPs, such as time constraint, limited resources, and lack of professional training; these challenges have already been identified as barriers to NGSS implementation (Trygstad et al., 2013). Educational leaders must address learning demands of new policies to provide teachers with the support and resources necessary to support implementation. All teachers in this study indicated the need for ongoing professional development (Hagg & Megowan, 2015; Pruitt, 2015). Analysis of the data in this study identified a variation in implementation of the eight SEPs.

The data highlighted frequent integration of SEP 6, *Constructing Explanations and Designing Investigations*. This could indicate a high-level of PCK in this domain for the teachers in this study. Despite the fact that an ability to construct explanations in science education is deemed important, researchers have found gaps in the way explanations are taught in the classroom (Dagher & Cossman, 1992; Sandoval, 2003). For example, previous science standards such as the NSES emphasized the accumulation of facts and information rather than requiring students to reason out the underlying logic and process of an explanation. Under the NGSS, students must construct scientific explanations to promote scientific literacy. Constructing scientific explanations is a central practice of students in reform-oriented classrooms (American Association for the Advancement of Science, 1993; Duschl et al., 2007; Harrison & Treagust, 2000; Millar & Osborne, 1998; Mortimer & Scott, 2003; NRC, 1996; Osborne & Dillon, 2008; Treagust & Harrison, 2000) and figures prominently in the NGSS.

In contrast, SEP 4, *Analyzing and Interpreting,* had lower levels of implementation. Low levels of implementation could indicate a low level of PCK and class dynamics. Teachers who taught struggling learners indicated some SEPs were a challenge to implement. The NSES emphasized the importance of integrating math and science in preparing students to be scientifically literate. Although previous researchers have supported the integration of math and science (Hurley, 2001; Stevenson, & Carr, 1993), the low levels of implementation of SEP 4 by teachers in this study implies its practical support is not well-explored (Czerniak, Weber, Sandmann, & Ahern, 1999). NGSS emphasize the importance of math and science integration. As previously stated, teachers need to have a PCK base that enables them to make content understandable to their students (Shulman, 1986). Due to the complexities of the NGSS SEPs, implementation must be strategic and thoughtful when structuring classroom time to reach the depth of knowledge prescribed in the NGSS. The teachers in this study collaborated with grade-level peers to share ideas, new strategies, and impediments that occurred during implementation. Teacher collaboration is an effective strategy for teacher learning; previous research focused on the importance of teachers' professional communities (Desimone, 2002).

During the initial phase of implementation, there were gaps within the curricular innovation and lack of alignment with the textbook, which created a mismatch between the goals of the curriculum reform and teachers' perceptions of the reform. The NRC (2001) described the difficulty in achieving alignment due to decisions being made at various levels within the process. The district has since made strides in developing a resource hub with links to the NGSS website and the NSTA website. Educative curriculum features were included in the curriculum materials given to the teachers. The websites provide tools to assist teachers in developing NGSS lessons using the EQUip rubric (Achieve, Inc., 2014), as well as information related to curriculum planning, classroom resources, and professional learning. These resources are consistent with research from Ball and Cohen (1996), Davis and Krajcik (2005), and Remillard (2005), which suggests that educative curriculum materials are supportive to teacher learning.

Recommendations

Teachers in this study perceived that successful implementation of the NGSS SEPs requires a shift in instructional practices (see Tables 7-14 in Chapter 4). It was recommended that the district continue to provide ongoing professional development so teachers can implement the NGSS SEPs with fidelity (see Table 15). Professional development offers an opportunity to leverage teachers' initial understanding of the goals of the NGSS, promote teacher reflection, and sustain sense-making related to teachers' understanding of the NGSS (Allen & Penuel, 2014). Although most teachers had varied implementation levels of the NGSS SEPs, not all the subsections were implemented equally, which suggests a lack of understanding. As Reiser (2013) cautioned, it is not enough that teachers know the eight NGSS SEPs, they must also know how they work.

Table 15

Recommendations for Implementation of NGSS SEPs

Finding	**Related Recommendations**
Shift in Instruction	Continue to design lessons that allow autonomy for student-led learning. Continue to provide a classroom environment that encourages science teaching and learning with the constructs of science proficiency to move science education toward the vision supported by the NGSS Framework (Grooms, Enderle, & Sampson, 2015).
Implementation Barriers	Ongoing professional development is needed for teachers to implement the NGSS SEPs with fidelity. The NRC (2012) identified the need at the local, state, and national levels to increase content and pedagogical content knowledge in teachers implementing the new standards. Onsite training, such as modeling for teachers, should be provided throughout the implementation process, especially at the initial stage (Penuel, Gallagher, & Moorthy, 2011).
Curriculum Resources	Continue to use multiple resources that are aligned to the NGSS. Teachers need to utilize the NGSS website, which has multiple resources and tools that provide criteria to align lessons and units with the NGSS, including the EQuiP Rubric (Achieve, Inc., 2013b).
Grade Level Planning	School leaders should produce schedules to create supportive learning communities with grade-level colleagues to collaborate, debrief, and problem-solve about new teaching strategies; in addition, time should be provided for science educators to collaborate across grade levels to encourage vertical planning. Evidence from a wide range of studies of schools engaged in reform suggest that those that make extensive use of teacher collaboration are particularly successful in promoting implementation, in part because reform has more authority when embraced by peers (Bryk & Schneider, 2002).
Teacher Reflection	Continue to reflect on the successes and challenges of instructional activities used; modify instruction as needed. Reflective teachers seek and try new approaches to improve lessons (Stronge, 2007).

Note. NGSS = Next Generation Science Standards; SEPs = Science and Engineering Practices; NRC = National Research Council

The following specific recommendations are offered:

1. The state and district need to provide ongoing professional development to train teachers on the full understanding of each NGSS SEP. Without understanding the multilayers of the NGSS SEPs teachers have an incomplete and distorted view of the expected demands of the NGSS; there is a need for teacher leaders to provide school-based support on a regular basis. Data derived from all 12 participants indicated that teachers implemented the SEPs at varied levels. The data also showed that teachers exhibited weakness in implementing SEP 4, *Analyzing and Interpreting Data*; SEP 4 was only observed three times across the 39 observations. Because the implementation varied from school to school and teacher to teacher, professional development needs to be job embedded based on each school's specific needs.
2. It is important to acknowledge that new policies require resources, more time for teachers to plan and collaborate with peers, and support from administration. All 12 participants indicated there was a lack of resources, the need for more planning time, and the value of collaborating with peers. School administrators are critical for the successful implementation of external reforms. Each school within this district operated on a school-based budget. The principals are key decision makers, problem solvers, and change agents at the school level. School leaders need to seek and provide stable funding and create schedules that accommodate grade-level and content-area planning time. The 12 participants acknowledged developing learning communities within their departments to collaborate, share strategies, and plan lessons.

3. The implementation of the NGSS SEPs will not be without challenges. The key to successful large-scale reforms is to involve stakeholders on every level: state, district, universities, colleges, educational organizations, teachers, parents, and students. Each level plays an important role in the broader goal for student achievement. The state regulates and allocates funding to the district; the district provides professional development to the school leaders and teachers; the universities, colleges, and educational organizations offer courses to enhance teachers' PCK of the NGSS, and teachers provide innovative and creative learning environments for students.
4. More research is needed on a large scale to see what patterns emerge related to the implementation of the SEPs as well as the planning and lesson designs phases of the NGSS SEPs
5. More research is needed on the importance of student self-regulation and the need for teachers to focus on it.
6. Educational leaders must design strategies for addressing the learning demands of new policies on themselves and classroom educators; that is, they must plan how to help everyone learn about the new standards and the changes to practice those standards demand or imply (Cobb & Jackson, 2012). Leaders must also identify and activate the human, social, and material resources necessary to address these learning problems and support implementation (Spillane, Diamond, Walker, Halverson, & Jita, 2001).

Conclusions

Although all eight SEPs were observed during the scope of this study, all teachers indicated that they incorporated more SEPs than I was able to observe within the limits of the 10-week period. To analyze data, I used a triangulation of information that included interviews, field notes, and observations. The NGSS (Achieve, Inc., 2013b) highlight an educational goal for students to engage in authentic science. This goal is not inclusive of how teachers are to implement the new reform into their classroom. The NGSS along with *A Framework for K-12 Science Education* (NRC, 2012) articulated the integration of eight SEPs as the most evident shift in science instruction. Teachers in this study embraced the demands of the NGSS SEPs to shift the teaching and learning in their classroom. Despite these facts, the participants' knowledge of the NGSS SEPs was not uniform. Although the 12 participants had uneven levels of implementation overall of the NGSS SEPs, the teachers needed a greater depth of knowledge to effectively implement the new standards and practices (e.g., Reiser, 2013). As the implementation of the NGSS proceeds, both teachers and researchers will generate new understandings.

APPENDIX A

Teacher Interview Questions

Teacher Demographic information:

1. How do you describe yourself? (Ethnicity)
2. How many years have you been teaching? Grade levels?
3. What is your highest level of education?
4. What are your certifications?

Research Questions:

1. In a selected large urban Maryland school district, what are middle school science teachers' perceptions regarding instructional practices that needed to be modified to align with the NGSS and SEPs?
2. To what degree do middle school science teachers' perceptions regarding instructional practices align with key practices of the NGSS and SEPs?
3. What instructional practices do science teachers use to meet the demands of the NGSS and SEPs?
4. To what degree do instructional practices science teachers use align with key aspects of the NGSS and SEPs?

Interview Protocol: Instructional Strategies used in the implementation of the Next Generation Science Standards science and engineering practices.

1. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #1 Asking questions (for science) and defining problems (for engineering)?
2. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #2 Developing and using models?
3. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #3 Planning and carrying out investigations?
4. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #4 Analyzing and interpreting data?
5. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #5 Using mathematics and computational thinking?
6. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering

Practices #6 Constructing explanations (for science) and designing solutions (for engineering)?

7. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #7 Engaging in argument from evidence?
8. How do you believe that you need to modify (or have already modified) your instructional practices to meet the needs of the Science and Engineering Practices #8 Obtaining, evaluating, and communicating information?

APPENDIX B

Classroom Observation Protocol

Classroom Observation Protocol Teacher #: ________
The Next Generation Science Standards (NGSS): Science and Engineering Practices (SEPs) drive daily instruction

	Evident O-1	O-2	O-3	O-4
Practice 1: Asking Questions and Defining Problems — **Observation=O**				
Asking questions				
• that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.	_____	_____	_____	_____
• to identify and/or clarify evidence and/or the premise(s) of an argument and challenge the premise(s) of an argument or the interpretation of a data set.	_____	_____	_____	_____
• to clarify and/or refine a model, an explanation, or an engineering problem.	_____	_____	_____	____
• that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	_____	_____	_____	____
Define a design problem that can be solved through the development of and object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	_____	_____	_____	_____
Practice 2: Developing and Using Models				
• Evaluate limitations of a model for a proposed object or tool.	_____	_____	_____	_____
• Develop or modify a model-based on evidence-to match what happens if a variable or component of a system is changed.	_____	_____	_____	_____
• Use and/or develop a model of simple system with uncertain and less predictable factors.	_____	_____	_____	_____
• Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.	_____	_____	_____	______
• Develop and/or use a model to predict and/or describe phenomena or unobservable mechanisms.	_____	_____	____	_____
• Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at observable scales.	_____	_____	_____	____
Practice 3: Planning and Carrying Out Investigations.				
• Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support the claim.	_____	____	_____	_____
• Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.	_____	_____	_____	____
• Evaluate the accuracy of various methods for collecting data.				
• Collect data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.	_____	_____	____	____
• Collect data about the performance of a proposed object, tool, process or system under a range of conditions.	_____	____	____	_____
Practice 4: Analyzing and Interpreting Data				
• Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.	____	_____	_____	_____
• Distinguish between casual and correlational relationships in data.	_____	_____	_____	_____
• Analyze and interpret data to provide evidence for phenomena.	_____	_____	_____	_____
• Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.	_____	_____	_____	_____
• Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).	_____	_____	_____	_____
• Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria success.	____	_____	_____	______
Practice 5: Using Mathematics and Computational Thinking				
• Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.	____	____	_____	_____
• Use mathematical representation to describe and/or support scientific conclusions and design solutions.	____	_____	____	_____
• Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.	____	____	____	_____
• Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	____	____	_____	____
Practice 6: Constructing Explanation and Designing Investigations				
• Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.	_____	_____	_____	_____
• Construct a scientific explanation using models or representations based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	_____	_____	_____	_____
• Apply scientific ideas, principles, and/or evidence to construct, revise and/or use and explain-ation for real-world phenomena, examples, or events.	____	_____	______	_____
• Apply scientific reasoning to show why the data or evidence is adequate for the explanation	_____	_____	_____	______

or conclusion.

- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. _____ ______ _____ ______
- Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing. _____ _____ ______ ____

Practice 7: Engaging in Argument from Evidence

- Compare and critique two arguments on the same topic and analyze whether they emphasize similar different evidence and/or interpretations of facts. _____ ____ _____ _____
- Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. ____ _____ _____ _____
- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for phenomenon or a solution to a problem. _____ ____ _____ _____
- Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. _____ ____ _____ _____
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. _____ _____ _____ _____

Practice 8: Obtaining, evaluating, and communicating information

- Critically read scientific texts adapted for classroom use to determine the central ideas and/ or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). ____ _____ _____ _____
- Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. _____ _____ _____ _____
- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. _____ ______ ______ _____
- Evaluate data, hypotheses, and/or conclusion in scientific and technical texts in light of competing information or accounts. _____ ______ ______ _____
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. _____ ______ ______ ______

APPENDIX C

Research Application

Research Title: ____

____

INSTRUCTIONS: Type requested information in the spaces provided. Enter check marks in appropriate blocks where answer options are provided. All requests to conduct research must be accompanied by one copy of each of the following: a complete research proposal, summary of that proposal (summary should contain no more than five pages and must include no less than: (1) Research Project Description; (2) Hypotheses/Assumptions; (3) Significance; (4) Methodology/Procedures; and (5) Specific Benefits to, completed research application, parental consent form/letter, and all data gathering instruments. <u>Please note that</u> <u>failure to provide all requested information will affect the time required to process your</u> <u>research application</u>.

A. IDENTIFICATION OF APPLICANT

1. Name of Applicant

[ ] Mr. [ ] Mrs. [ ] Miss [ ] Ms. [ ] Dr.

____

Mailing Address ____

Primary Telephone Number ________ - ____________________________
Area Code Number

Business Address ____

____

______________________________ Zip Code ______________

Business Telephone Area Code Number

Business Fax _____ Area Code Number ____________

E-mail address ____

Your Professional Position (check one)

[ ] Principal
[ ]Teacher
[ ] Research Assistant
[ ] Project Director
[ ] Student Teacher/Intern
[ ] Professor
[ ]Teaching Asst.
[ ] Research Associate
[ ] ______________________________
Other (please specify)

[ ] Yes [ ] No

b) If yes, check which of these answers applies to you?

[ ] Full-time employee [ ] Part-time Employee

[ ] Employee on Leave

3. Indicate whether you are proposing this study as:

[ ] A district Office, Department or Program Unit

____
(please specify)

[ ] In response to a request for proposals (RFP) or grant announcement.

Specify source of RFP:_______________________________

[ ] An individual researcher

[ ] An external research organization

4. a) Are you proposing this study in connection with the degree requirements of a college or a university, for yourself or any other person(s)?

[ ] Yes (If yes, answer parts b and c of this question.)

[ ] No (If no, skip to question 5.)

b) Which degree requirements?

[ ] Masters [ ] Doctoral [ ] Other _______________
(please specify)

c) Who is your advisor or committee chairperson?

Name _________________________ Tel. No.__________________

Institution____

Department in Institution ___________________________________

Note: Questions regarding this proposal may be directed to the above-named chairperson.

d) What is the approval status of your proposal at your college or university?

[ ] Formally approved (attach approval form)

[ ] Approved by advisor but not yet by dissertation committee

[ ] Not yet at the approval stage

[ ] Other (specify)

5. a) List the name(s), position(s) of individuals related to this study, institutional affiliations and of all persons who will use the data generated by this study for higher education degrees, grant applications, or publication purposes (attach additional sheets if necessary):

Name	Institution	Department	Position

b) Indicate your current degree status:
[ ] Non-degree [ ] Baccalaureate
[ ] Master's [ ] Doctoral

c) If you are applying as an individual, briefly describe your area of research specialization and your credentials:

6. How are the costs of this proposed study being financed?
[ ] by applicant [ ] By district program funds
[ ] by government foundation, or other research grant
(Identify source and/or briefly explain: ___________________________
____

7. **Budget**

a) Total budget for research related to this project
[ ] no external budget [ ] $100,000 - $150,000
[ ] less than $5,000 [ ] $150,000 - $200,000
[ ] $10,000 - $50,000 [ ] $200,000 - $250,000
[ ] $50,000 - $100,000 [ ] $250,000 +

b) What amount will be budgeted for conducting this research in district?
$__________________(dollar figure)

c) What amount will district receive for participating in this research?
$__________________(dollar amount)

d) What amount will researcher budget as in-kind contribution?
$_________________ (dollar figure) Type (salaries, equipment, etc.):
____

e) What amount is budgeted to compensate research participants?

Participant________________________________ $______________________
(student, teacher, etc.) (dollar amount)

B. PROPOSED STUDY FRAMEWORK

1. Title of Research ____

____

2. The area(s) of research:

[ ] Special Education
[ ] Literacy Instruction
[ ] Instructional Technology
[ ] Early Childhood Education
[ ] Family and Community Engagement
[ ] Safe and Supportive Schools
[ ] Talent/Professional Development
[ ] College and Career Readiness
[ ] High-Performing Workforce
[ ] Other (specify)_________________

3. Hypotheses and/or objectives of research______________________________

____

4. Type of school research site(s) required:

[ ] Intact Classrooms [ ] Student's home environment
[ ] Other (specify)____

5. Name (if known)/type of proposed district school/site(s):

____
____

6. Proposed starting date ____

7. Proposed completion date ______________________________________
(Proposals approved for one year; must request extension if needed)

C. REQUIREMENTS FOR SUBJECTS

1. Will students be required as subjects for this study? **<u>Note: This includes collecting data directly from students and/or the use of existing student data from the district</u>.**
[ ] Yes (If yes, answer parts a, b, c and d of this question.) [ ] No (If no, skip to question 2.)

a) Enter grade and number of students requested under the headings provided here.
<u>Note: This information must be provided if student subjects are included.</u>

			Total
Grade ______	Male ______	Female ______	______
Grade ______	Male ______	Female ______	______
Grade ______	Male ______	Female ______	______
Total	______	______	______

b) Check and describe any specific criteria for selection of students to take part in the study:

[ ] Ability level (specify)____
[ ] Socioeconomic level(s) ______________________________________
[ ] Ethnic, racial background ____________________________________
[ ] Physical characteristics ______________________________________
[ ] Clinically identified conditions _______________________________
[ ] History of personal problems (explain): _________________________
[ ] Other (specify) ____

c) Procedures which will be used to gather data from students:

[ ] Group Testing	[ ] Questionnaires
[ ] Individual testing	[ ] Observation
[ ] Interviews - face to face	[ ] Inventories
[ ] Interviews – telephone	[ ] Other (specify)

d) Are file data on students required?
[ ] Yes [ ] No

If yes, specify tests, scores, type(s) of other information and the period for which data are needed: ____
____
____
____
____

2. Will school staff, parents, or former students be subjects in the study?

[ ] Yes (If yes, answer parts a, b, c, and d of this question.)
[ ] No (If no, skip to E)

a) Give subject category and number (REQUIRED):

Subjects	Total Number of Subjects
[ ] Classroom Teachers	______________________
[ ] Counselors	______________________
[ ] School-based Administrators	______________________
[ ] Central Office Administrators	______________________
[ ] Parents	______________________

b) Are file data on staff requested? [ ] Yes [ ] No
(If yes, specify and discuss how data will be used)

c) Are file data on parents requested? [ ] Yes [ ] No
(If yes, specify and discuss how data will be used)

d) Are archival data on former students or graduates and/or their families requested? [ ] Yes [ ] No
(If yes, specify and discuss how data will be used)

D. REQUESTED PARTICIPATION OF District STAFF

a) Will the district staff assistance be requested? [ ] Yes [ ] No

b) If yes, which staff?
[ ] Teachers [ ] Principals
[ ] Other (specify)____

c) Describe tasks staff will be asked to perform.

____

____

____

d) Will staff be compensated? [ ] Yes
[ ] No

If Yes, how and/or in what amount? $_______________ (total staff compensation)
OR $________________ (per) (dollar amount) (as designated by researcher)

E. INSTRUMENTS, EQUIPMENT AND INSTRUCTIONAL MATERIALS

1. What tests, observation guides, questionnaires, attitude scales, interest inventories, and other typed or printed instruments will be used? Specify below and enclose one (1) copy:

Is Instrument
Est. Time Type of Name or Description Researcher
Made? Required to Instrument of Instrument
Yes No Administer

[ ] Group Test ________________________ [[ ]]Indi[vid]ual Test ___[ ] Question[na]ire [ ] ______
protocol ________________________ [ ] Observation
guide ________________________ [[ ]]Atti[ude]e/interest ___________ [ ] [ ]
inventory ________________________ [[ ]]Othe[r (]spec.) ____________

2. What instructional materials will be used for research purposes? (Specify or indicate "none.") [ ] None

F. ATTACHMENTS

Check items which you are attaching to this application:

[ ] One copy of application
[ ] One complete proposal (REQUIRED)
[ ] One copy of the proposal summary (REQUIRED)
[ ] Parental consent letter/form (**In addition to a space for the parent's or guardian's signature, the parent consent form <u>MUST</u> have spaces to write out the student's and the parent/guardian's name)**
[ ] All instruments
[ ] Thesis committee approval form (STUDENT REQUIREMENT)
[ ] Other (describe)____

G. SIGNATURES

1. Studies proposed by School System employees require the signature of the applicant's immediate supervisor (i.e., principal, director, regional director, etc.).

Acknowledged:____
Signature

Date________ Title__________________________________

Office/School____

2. SIGNATURE OF THESIS COMMITTEE CHAIRPERSON
The following is to be signed by the chairperson of the applicant's thesis committee:

I have reviewed the enclosed research proposal and find it to be technically competent, theoretically sound, and significant in focus.

I understand that I may be contacted by district regarding this proposal.

Name ________________________________ Date ________________
Signature

Title____

3. APPLICANT SIGNATURE

I understand that acceptance of this request for approval of a research proposal in no way obligates large urban school district to participate in this research. I also understand that approval does not constitute commitment of resources or endorsement of the study or its findings by the school system or by the School Board.

I acknowledge that participation in research studies by students, parents, and school staff is voluntary. I will preserve the anonymity of all participants in the reporting of this study. I will not reveal the identity or include identifiable characteristics of schools or of the school system unless authorized by the Testing, Research and Evaluation office.

I have read Board Policy 5125.4 and Administrative Procedure 4131.34 and understand that I must comply with all requirements as stated. If approval is granted, I will abide by all district policies and regulations and will conduct this research within the stipulations accompanying any letter of approval. At the completion of the study, I will provide district with one (1) bound copy of the research results.

____ __________________

Applicant' Signature Date

Please send one (1) copy each of: this application, complete proposal, proposal summary, parental consent form/letter, and data gathering instruments to:

DIRECTOR, RESEARCH & EVALUATION

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VITA

Educational Background

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M.Ed. Adult Education/Administration, Coppin State University, Baltimore, MD (May 2009)
B.S. Premedical Biology, Virginia State University, Petersburg, VA (May 1991)

Professional Skills

- Assistant Principal
- Evaluator
- Data Analysis
- School Improvement
- STEM Coordinator
- Curriculum Development
- Professional Development
- Instructional Lead Teacher
- Science Department Chairperson
- New Teacher Academy Coordinator

Professional Experiences

- Assisting the principal in leading and implementing a cohesive educational program for assigned students in accordance with the Professional Standards for Educational Leaders
- Assuming responsibility for the operation of the school in the absence of the principal
- Analyzed and communicated school and student data to implement programs and activities to serve the needs of diverse student population and support curriculum standards.
- Assisting in the planning, development, implementation, and evaluation of instructional programs
- Participating in a variety of student activities; collaborating with special services personnel, assisting in the maintenance of standards concerning students' discipline, health, safety, and general welfare

- Assisting in a variety of administrative responsibilities.

Professional Experiences (cont'd)

- Analyzed and communicated school and student data to implement programs and activities to serve the needs of diverse student population and support curriculum standards.
- Public relations experience; ability to handle difficult situations diplomatically.
- Thrive on accepting new challenges.
- Train teachers to teach effectively using the mandated curriculum.
- Created, planned and implemented a professional development calendar that focused on student achievement and school improvement. (2005-present)
- Wrote the curriculum for Science grades 6-8 (2005-present); HS Forensic Science (2013)
- Evaluated student teacher final portfolios in University of Maryland's Teacher Preparation Program.
- Utilized technology to implement effective instruction to serve the needs of diverse learners.
- Outstanding communication and interpersonal skills.
- Experience working with individuals from diverse backgrounds.
- Motivate our students to explore science on a higher level than expected.
- Knowledgeable of Science pedagogy and best teaching practices
- Mentor/Lead Teacher to new teachers in Residential teaching program and the Teach America Program.