PRESERVICE SPECIAL EDUCATION TEACHERS’ UNDERSTANDINGS, ENACTMENTS, VIEWS, AND PLANS FOR SCIENTIFIC INQUIRY: ISSUES AND HOPES

A dissertation submitted to the Kent State University College of Education, Health and Human Services in partial fulfillment of the requirements for the degree of Doctor of Philosophy

By
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This study examined the understandings, enactments, views, and plans for scientific inquiry held by preservice special education teachers enrolled in a K–8 general science methods course. Sixteen participants from four special education concentration areas—Mild to Moderate Educational Needs, Moderate to Intense Educational Needs, Mild to Moderate Educational Needs with Language Arts and Reading Emphasis, and Early Childhood Intervention—participated in this study. Qualitative data were collected from questionnaires, interviews, teaching videos, lesson plans, planning commentaries, and reflection papers. Data were analyzed using a grounded theory approach (Strauss & Corbin, 1990) and compared against the theoretical view of inquiry as conceptualized by the National Research Council (NRC, 2000). The participants held unique interpretations of inquiry that only partially matched with the theoretical insights provided by the NRC. The participants’ previous science learning experiences and experiences in special education played an important role in shaping their conceptualizations of inquiry as learned in the science methods class. The impacts of such unique interpretations are discussed with reference to both science education and special education, and implications for teacher education are provided.
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CHAPTER I
INTRODUCTION

In the arena of science education, scientific inquiry or inquiry is considered an active learning process where students learn by answering research questions through data collection and data analysis (Crawford, 2014). Stemming from John Dewey’s (1916) philosophy of experience-based education, inquiry involves a hands-on, minds-on approach to learning of science through direct, first-hand experiences (Barrow, 2006). The National Research Council (NRC) in its National Science Education Standards (NSES; NRC, 1996) indicated that inquiry learning involves both doing of inquiry (the practice of inquiry) and learning about the nature of scientific inquiry (NRC, 1996).

While inquiry learning encourages students to learn by connecting data or evidence to scientific explanations, teachers play a crucial role in guiding students toward their learning by inquiry (Crawford, 2014; NRC, 1996, 2000). By teaching science as inquiry, teachers facilitate student’s use of certain abilities associated with scientific inquiry and support the development of these abilities in students (NRC, 1996, 2000). Specific abilities that teachers help promote in their students while teaching using inquiry include asking scientifically-oriented questions, conducting investigations, collecting data, interpreting data as evidence, exploring and evaluating alternative explanations and communicating scientific arguments (NRC 1996, p. 105).

Inquiry instruction holds great promise for teaching science to students (Abrams, Southerland, & Evans, 2007; American Association for the Advancement of Science [AAAS], 1989, 1993; Barrow, 2006; Bybee, 2000; Crawford, 2014; NRC, 1996, 2000).
Inquiry instruction gives students the opportunity to actively engage in direct, authentic experiences and make sense of science concepts by using logic and scientific reasoning (NRC, 1996, 2000). By placing emphasis on understanding the meaning of concepts rather than rote memorization (Barrow, 2006), learning by inquiry promotes both understanding and engagement in science (NGSS Lead States, 2013; NRC, 1996, 2000). Inquiry promotes scientific literacy (Abrams et al., 2007; Bybee, 2000) and allows students to evaluate multiple possible answers instead of the right answer (Roth, 1995, 1996). Inquiry also allows teachers to explore ideas and experiences of students, identifying potential misconceptions and address them using evidence and logic (Ochanji, 2008).

The learning and teaching of inquiry, however, is not free from debate (Crawford, 2014; Osborne, 2014). Inquiry has no universal definition or steps that delineate its implementation (Anderson, 2002; Abrams et al., 2007; Crawford, 2014), the lack of which has resulted in multiple interpretations of inquiry, making inquiry sometimes difficult to understand or practice (Abrams et al., 2007; Blanchard et al., 2010; Crawford, 2014; Osborne, 2014). While some interpretations of inquiry have supported science learning in K–12 classrooms (Bell, Blair, Crawford & Lederman, 2003; Blanchard et al., 2010; Gibson & Chase, 2002; Yager & Akçay, 2010), other interpretations have questioned the efficacy of inquiry with K–12 students (Cobern et al., 2010; Kirschner, Sweller, & Clark, 2006; Klahr & Nigam, 2004). Difficulty in practice has been reported in both inservice (Capps, Crawford, & Constas, 2012) and preservice (Crawford, 2007) science teachers as well. Nevertheless, inquiry instruction has gained strong empirical
support in K–12 classrooms (Crawford, 2014) and reviews of empirical studies have indicated a positive trend between inquiry science learning and teaching using inquiry (Minner, Levy, & Century, 2010; Schroeder, Scott, Tolson, Huang, & Lee, 2007; Shymansky, Kyle, & Alport, 1983). Inquiry instruction, if taught to teachers appropriately, can support science learning in K–12 students (Blanchard et al., 2010). Guided inquiry has seen stronger empirical support than unguided or totally teacher-directed inquiries (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011; Blanchard et al., 2010; Furtak, Seidel, Iverson, & Briggs, 2012) highlighting the significance of the role of teachers during effective inquiry instruction.

**Rationale for Study**

In the realm of special education studies, little empirical research has been conducted regarding the effect inquiry-based education (Courtade, Spooner, & Browder, 2007; Rumrill, Cook, & Bellini, 2001; Therrien, Hughes, & Hand, 2011). Initially viewed with skepticism and doubt (see Ellis, 1993; Woodward & Noell, 1992), teaching and learning by inquiry have achieved gradual acceptance in the special education community. Empirical research studies have indicated positive outcomes such as learning and engagement in science in a variety of learners with disabilities (Dalton, Morocco, Tivnan, & Mead, 1997; Knight, Smith, Spooner, & Browder, 2011; Mastropieri & Scruggs, 1994; Mastropieri, Scruggs, & Butcher, 1997; McCarthy 2005; Melber & Brown, 2008; Palincsar, Collins, Marano, & Magnusson, 2000; Schmidt, Gillen, Zollo & Stone, 2002; Scruggs & Mastropieri, 1994, 1995; Scruggs, Mastropieri, Bakken, & Brigham, 1993). Though several groups of students with disabilities have yet to be
researched, the above studies clearly identified how special education teachers play a critical role in supporting learners with disabilities in inquiry classrooms.

Interestingly, even after identifying the positive role of special education teachers’ guidance during inquiry instruction, little to no research has been conducted on inquiry learning of special education teachers, the majority of whom are the providers of meaningful guidance during successful inquiry. The present study aims to address this gap in research by exploring the ways in which inquiry is conceptualized by prospective teachers in special education as they learn about inquiry. More specifically, this study examined how special education teacher candidates defined and characterized inquiry, enacted inquiry instruction, viewed and planned for inquiry while learning about inquiry in a general science methods class. This study compared participants’ responses to NRC’s (2000) version of inquiry identifying matches and mismatches between participants’ interpretations of inquiry and the NRC’s version to develop newer insights in teacher education of both science and special education teacher candidates.

**Defining Inquiry for This Project**

Among various interpretations of inquiry, the NRC’s (2000) version of inquiry served as the operational framework of inquiry in this project. In this document, the NRC delineates five specific practices that NRC encourages learners to engage in while learning science by inquiry (Abrams et al., 2007; Anderson, 2002; Crawford, 2014). The NRC endorsed five practices as five essential features of classroom inquiry: (a) Learners are engaged by scientifically oriented questions; (b) Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically
oriented questions; (c) Learners formulate explanations from evidence to address scientifically oriented questions; (d) Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding; and (e) Learners communicate and justify their proposed explanations (NRC, 2000, p. 25). These essential features (NRC, 2000) are not uniform, but can vary along the teacher-learner continuum with varying amounts of guidance provided by teachers to accomplish learning in students. Inquiry lessons can range from being “totally student-centered” (unguided or open) to being “fully teacher-directed” (verification labs) depending upon the amount of guidance given by teachers to support students’ learning by inquiry (NRC, 2000, p. 29).

The five features (NRC, 2000) are embedded in the Scientific and Engineering Practices (NRC, 2012) that replace “inquiry” in the new science standards (NRC, 2012) today. The replacement does not, however, signify a decrease in the significance of inquiry since both the new K–12 Framework (NRC, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013) acknowledge that such replacement reflected the NRC’s effort “to make inquiry more applicable” (NRC, 2012, p. 2) (Crawford, 2014). The earlier versions (including NRC, 2000) remained fundamental to the development of Practices (NRC, 2012) in the new standards (NGSS Lead States, 2013, p. 301). But since Practices (NRC, 2012; NGSS Lead States, 2013) conflate inquiry with other constructs such as engineering and the nature of science (see Lederman & Lederman, 2014; Padilla & Cooper, 2012) and this research explicitly focused on learning and teaching of science by inquiry, the NRC’s (2000) version was
selected as the operational definition of inquiry for this project. The five essential features (NRC, 2000), which have strong empirical support in research with both K–12 students and general science teachers (Blanchard et al., 2010; Crawford, 2014), have been used as a theoretical framework of inquiry in this study. The participants consisted of preservice teachers in special education, a group of teachers whose inquiry conceptions have not been studied before.

**Purpose Statement**

This study had two purposes: (a) to explore preservice special education teachers’ understandings, enactments, views and future plans for inquiry; and (b) to compare these understandings, enactments, views and future plans to the NRC’s (2000) version of inquiry. More specifically, participants’ *understandings* of inquiry were studied in terms of how participants defined (described *what inquiry is*) and characterized (described *how inquiry is done*) inquiry. Participants were first taught about inquiry and the five essential features (NRC, 2000) using various experiences in a K–8 general science methods class, after which their understandings, enactments, views, and future plans were studied and compared against the NRC’s version of inquiry. The participants represented a population of teachers whose inquiry conceptions have not been studied previously, but may teach science in diverse instructional settings (Varma, Volkmann, & Hanuscin, 2009). A study of their understandings, enactments, views, and future plans for inquiry and a comparison of their interpretations to the established NRC (2000) document were conducted to provide newer insights to learning, teaching, and adapting inquiry for diverse learners in diverse instructional settings.
Research Questions

In this qualitative research, the terms *inquiry* and *the five essential features* (NRC, 2000) are treated synonymously. The following four research questions that guided this dissertation likewise employs these terms interchangeably. Participants’ *understandings* of inquiry included the study of how participants defined (described *what inquiry is*), characterized (described *how inquiry is done*) and enacted inquiry instruction (taught science using inquiry) in the context of the science methods class.

Considering the lack of a definition for inquiry in literature (Anderson, 2002; Crawford, 2014), I wanted to examine how preservice special education teacher candidates considered scientific inquiry following experiences in the NRC-aligned science methods class. Taking note of preservice general science teachers’ struggles with the enactment of inquiry instruction (Crawford, 2007; Hancock & Gallard, 2004; Leonard, Boakes, & Moore, 2009; Lustick, 2009; Windschitl, 2003, 2004), I wanted to examine how special education teacher candidates, who represent a unique population of teachers again, performed their earliest teaching using inquiry. Given that inquiry and its features (NRC, 2000) so highly encouraged (AAAS, 1993; NRC, 1996, 2000; National Science Teachers Association [NSTA], 2004), I wanted to examine views about inquiry held by the participants. Finally, keeping in mind the variety of instructional settings that exist for teaching science to diverse learners (Arndt & Liles, 2010; Bouck, 2007; Vannest et al., 2009) and that teachers have reported struggles with teaching science in certain settings (Bouck, 2007; Crawford, 2007; Everhart, 2009; Gately & Hammer, 2005; Irving, Nti, & Johnson, 2007; Moin, Magiera, & Zigmond, 2008; Shippen, Crites, Houchins, Ramsey,
& Simon, 2005), I wanted to examine what choices the participants made toward their future science teaching using inquiry or the five features (NRC, 2000). From these insights, the four research questions, as previously noted, emerged. Thus, these four research questions guided this dissertation:

1. How do preservice special education teachers define and characterize scientific inquiry in a general science methods class?
2. How do preservice special education teachers enact their inquiry instruction in the context of a science methods course?
3. What are these preservice special education teachers’ views on teaching using scientific inquiry?
4. To what extent do preservice special education teachers plan to incorporate inquiry instruction in their future science classrooms?
   a. What reasons do they offer to explain their inquiry inclusion decisions?
   b. For those who intend to incorporate inquiry instruction in their future teaching, how do they envision utilizing this method?

List of Definitions

The following section contains key terms and concepts relevant to the research, organized in alphabetical order:

**Confirmation lab**: Inquiry-based lesson in which teacher provides questions, methods, and solutions. Students confirm what teachers say.

**Discrepant event**: Science activities that allow teachers to introduce and teach science concepts by specific hands-on explorations and reasoning (Wright &
Govindarajan, 1995). These events allow teachers to assess students’ initial ideas, set up and demonstrate the discrepancy, allow students to investigate the discrepancy, resolve the discrepancy, and assess for students’ changed ideas.

**Discrepant EVENT Microteaching:** Small (20-minute) teaching presentations in the methods class during which teacher candidates use a discrepant event to teach a K–8 science lesson.

**Five E Learning Cycle Model:** Model for instructional planning of inquiry-based lessons conceptualized after Bybee (1997, 2000). Five components include Engage (get students interested and involved in the lesson, assess prior knowledge in students); Explore (provide students with the opportunity to get directly involved with phenomena); Explain (allow students to communicate what they have learned so far and figure out what it means); Extend (allow students to expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to other situations); and Evaluate (assessment of learning).

**Five essential features of inquiry:** The NRC (2000) characterized inquiry with five components where the learner asks scientifically-oriented questions, learner gives priority to evidence in responding to questions, learner formulates explanations from evidence, learner connects explanations to scientific knowledge, and learner communicates and justifies explanations.

**Guided inquiry:** Inquiry-based lessons in which teacher provides questions but students identify methods and procedures.
**Inquiry instruction:** Teaching using inquiry; this incorporates encouraging learners to ask questions about science concepts, propose answers, collect and interpret data as evidence, explain answers in terms of evidence, and justify answers in terms of evidence.

**Inquiry-based microteaching:** Short (20-minute) teaching presentations in the methods class in which teacher candidates taught a K–8 science lesson using inquiry instruction.

**Microteaching:** Short (20-minute) teaching presentations conducted in the science methods class. These presentations were video-taped, and participants wrote their inquiry teaching reflection paper based on these videos.

**Open inquiry:** Inquiry-based lessons where students develop questions, identify methods, and propose solutions.

**Planning commentary:** A pre-teaching reflection paper where participants described the planning for their inquiry-based microteaching.

**Scientific inquiry:** An active learning process during which students answer research questions by collecting and interpreting data or evidence.

**Structured inquiry:** Inquiry-based lesson where teacher provides questions and methods but students formulate solutions.
CHAPTER II

LITERATURE REVIEW

This chapter identifies key literature studies pertaining to the teaching and learning of scientific inquiry and inquiry instruction in diverse instructional settings. Examined publications include empirical studies, chapters from books, handbooks, and seminal publications. Even though this study examines preservice special education teachers’ understandings, enactments, views, and plans for inquiry occurring in an inquiry-based general science methods course, I conducted this review both along a teacher-learner continuum and the general science education-special education continuum. Studies with K–12 students as participants revealed how K–12 learners participate in inquiry environments and how teachers provided guidance in these environments. Studies with science teachers (specifically preservice science teachers) highlighted how science teachers are taught about inquiry. Empirical studies with students from both general science education and special education contexts revealed how inquiry operates in respective contexts and how teachers (either general science teachers or special education teachers) facilitate student’s learning in either setting. Although the training and experiences of special education teachers can be completely different from that of general science education teachers (Rumrill et al., 2001), empirical research from both science and special education was reviewed to make this literature review meaningful to readers from both communities and strengthen the rationale for conducting this research.

The organization of the review is described as follows. This chapter begins with a brief *historical review of scientific inquiry*, tracing the emergence of inquiry to
philosophies of John Dewey (1916) and examining the position of inquiry in the country’s science education scenario. Following the historical review, this chapter provides an overview of teaching science using inquiry instruction in K–12 classrooms, reviewing empirical studies conducted with K–12 learners as participants. Under the broader umbrella of K–12 learners, empirical studies in general science classrooms are reviewed first, followed by studies with students with disabilities. This section examined the practice and efficacy of inquiry instruction in diverse K–12 settings in order to understand the role of teachers (either general science teacher or special education teacher) in supporting learners in the studied inquiry environments.

The chapter next proceeds to examine inquiry in science teacher preparation, analyzing how science teachers learn about inquiry during their science teacher preparation process. After briefly reviewing all possible opportunities received by science teachers to learn about inquiry at various stages of teacher preparation, the search focused on studies conducted in science methods courses since this context matches the context of the present study. This section focused on: (a) Preservice teachers’ learning about inquiry in a science methods course; (b) Preservice teachers’ enactment of inquiry instruction; and (c) Preservice teachers’ views of inquiry instruction. A majority of the studies here are qualitative in nature, but also included few studies that used other methods (such as mixed methods or quantitative studies) but have informed readers about the preservice teachers’ learning about inquiry. Although the present study is conducted in a K–8 general science methods course, I reviewed studies with preservice elementary,
middle school, and secondary science teachers since participants would teach K–12 special education.

I also reviewed empirical studies that examined *science teaching in diverse instructional settings*. Empirical studies conducted with preservice teachers in diverse instructional settings was examined here. One study was conducted in a history education class, but was included in this review since it explored co-teaching between science and special education teachers during their preservice phase. This chapter concludes with the *chapter summary*, identifying areas where this literature remains deficient and presents this study to address the gap in literature.

**A Brief Historical Review of Inquiry in Science Education**

In order to trace the emergence of scientific inquiry in the field of science education, it becomes essential to understand the philosophical and theoretical underpinnings of scientific inquiry. Teaching using scientific inquiry dates back to the ideal of experience-based education as fostered by John Dewey. Dewey (1916) recognized the role of personal experience in influencing learning in individuals (Barrow, 2006). In order to understand something new, Dewey emphasized that students need to experience concepts first-hand and then reflect on such experiences (Barrow, 2006; DeBoer, 1991). His philosophy was applied to the teaching and learning of science, where the learning of scientific concepts occurs through direct experiences and reflections on those experiences, rather than just memorization of facts (Schwab, 1962). Science education reform movements fostered Dewey’s approach to science education and encouraged hands-on and minds-on experiences for the learning and teaching of
science (Anderson, 2002; Barrow, 2006). For years, teaching using scientific inquiry has been emphasized in many countries, including the U.S.A. (Abd-El-Khalick et al., 2004; Anderson, 2002; Barrow, 2006; DeBoer, 1991). Being different from traditional, lecture-oriented methods of teaching science, inquiry instruction embraces a constructive paradigm where teachers and students actively take part in learning (Bybee, 1997, Colburn, 2000; Duschl & Osborne, 2008). Authentic inquiry involves learners to ask questions and search for possible answers, giving priority to evidence rather than to teachers providing the answer to students (Ochanji, 2008; Roth, 1995, 1996). This approach to teaching and learning of science is considered promising by national science education organizations like the American Association for the Advancement of Science (AAAS, 1989, 1993), the National Research Council (NRC, 1996, 2000, 2012), and the National Science Teachers Association (NSTA, 2004).

Scientific inquiry lacks a universal definition, and this ambiguity has created problems with its practice (Anderson, 2002; Capps & Crawford, 2013; Capps et al., 2012; Crawford, 2007). To address this lack of definition, science educators have repeatedly emphasized the theoretical underpinnings of a learning-by-doing approach to science education while conceptualizing scientific inquiry (Crawford, 2014). In the National Science Education Standards (NSES; NRC, 1996), the NRC, for the first time conceptualized inquiry from the learner’s perspective—what learners do in an inquiry environment and how learners build scientific knowledge by reflecting on what they did (Crawford, 2014). The NRC later developed the five essential features of scientific inquiry (NRC, 2000), indicating how inquiry can be practiced in K–12 classrooms. More
recently, to make inquiry more applicable in the K–12 classroom context (NGSS Lead States, 2013), the NRC introduced Science and Engineering Practices which replaces inquiry in the new standards (NRC, 2012). Still, the insights present in the earlier versions (NRC, 1996, 2000) such as learner’s involvement and experience-based education, continue to remain fundamental to teaching and learning of science even today (Crawford, 2014; NGSS Lead States, 2013; Lederman & Lederman, 2014; NRC, 2012; Osborne, 2014).

**Teaching Science Using Inquiry Instruction in K–12 Classrooms**

Dewey’s philosophy of experience-based education has allowed students to answer their research questions by giving priority to evidence their hands-on experiences have given them (Anderson, 2002). Hands-on merely means students are using materials, but inquiry means not just using the materials, but thinking and reflecting scientifically on the concepts being taught using those materials (Abrams et al., 2007; Barrow, 2006). Inquiry constitutes asking questions about scientific concepts, proposing answers, collecting and interpreting data as evidence to support proposed answers, explaining and justifying answers in terms of evidence, and learning science concepts by reflecting on these experiences (Barrow, 2006; Crawford, 2007, 2014). These experiences have been widely researched, with learners from diverse educational settings developing many versions of inquiry instruction in K–12 classrooms.

**Inquiry Instruction in General Education Classrooms**

Empirical research conducted on inquiry instruction with general science students indicates that an NRC-aligned inquiry instruction developed positive outcomes such as
enhanced knowledge and understanding of science content as well as engagement and motivation in K–12 students (Abell, 1999; Bell et al., 2003; Blanchard et al., 2010; Gibson & Chase, 2002; Yager & Akçay, 2010). A few other studies, however, have questioned the efficiency of inquiry instruction (Cobern et al., 2010; Kirschner et al., 2006; Klahr & Nigam, 2004). In one instance, Klahr and Nigam (2004) studied the effects of direct instruction and unguided, discovery learning in third- and fourth-grade learners and considered the latter as inquiry. Students in the discovery learning group received no teacher intervention other than suggestion of a learning goal, but in the direct instruction group, teachers provided all supporting materials, goals, examples, and explanations. The researchers found that students who received direct instruction fared better at learning science content than those who received the discovery learning approach. The study considered discovery learning to be synonymous to unguided (or minimally-guided) inquiry instruction, which can be markedly different from that held by others in the science education community (Blanchard et al., 2010). Additionally, this study used students’ judgment of posters as a measure of learning outcome rather than students’ ability to show gains on any standardized assessments. Furthermore, teachers told the direct instruction group about the result of the investigation ahead of time, which is not typical of most inquiry-based laboratory settings; students knowing the outcome might have influenced the results of the study. Nonetheless, the study is an example of an empirical research that conveyed diversity in conceptions and interpretations of inquiry.
More recently, Cobern et al. (2010) claimed direct instruction to be more effective than inquiry-based instructional approaches. In a quantitative study with 180 eighth grade students, the researchers randomly assigned participants to direct instruction or inquiry instruction classrooms during a voluntary summer science education program. Quantitative analysis of data indicated that learning gain differences between the two modes of instruction emerged as quite small and not statistically significant. The study found that student gains for different teachers within the similar instructional mode were not statistically significant. Although the researchers do not claim direct instructions to be better than inquiry, the study revealed a situation where both direct instruction and inquiry instruction remained equally effective. However, the study had certain methodological problems (such as the broad score distributions and limits on the power to determine the difference in scores) and had teachers with different teaching styles and practices and could have confounded the results. Despite this, the study remains another example of how inquiry is conceptualized and practiced (Blanchard et al., 2010).

Despite the lack of a concrete definition, more studies have found the NRC-aligned inquiry instruction to be useful for K–12 learners (Crawford, 2014; Minner, Levy, & Century, 2010). Given the conflicting results, inquiry instruction, not surprisingly, takes many forms in K–12 classrooms (Anderson, 2002; Blanchard et al., 2010; Crawford, 2014). Reviews of science education literature indicate a positive trend between inquiry-based instruction and the conceptual understanding of science of K–12 students (Minner et al., 2010; Shymansky et al., 1983). In addition, teacher-guided inquiry instruction is found to be more effective than verification labs or unguided inquiry lessons (Alfieri,
Brooks, Aldrich, & Tenenbaum, 2011; Blanchard et al., 2010; Furtak et al., 2012), indicating that teachers play a crucial role in inquiry learning environments.

**Inquiry Instruction for Learners With Disabilities**

As to exploring science teaching for learners with disabilities, a lack of empirical research largely remains (Courtade et al., 2007; Therrien et al., 2011). Considered initially with skepticism and doubt (Ellis, 1993; Woodward & Noell, 1992), inquiry-based instruction became gradually accepted by the special education community.

Before the emergence of federal mandates such as the No Child Left Behind (NCLB, 2001), inquiry instruction had been sporadically studied in contexts serving learners with disabilities, revealing positive outcomes in different instructional settings. Inquiry-based instruction conceptualized as hands-on activities has enhanced content knowledge, retention of learning, better comprehension of scientific concepts, engagement of learners and increased motivation in students with disabilities (Dalton et al., 1997; Knight et al., 2011; Mastropieri & Scruggs, 1994; Mastropieri et al., 1997; McCarthy, 2005; Melber & Brown, 2008; Palincsar et al., 2000; Schmidt et al., 2002; Scruggs & Mastropieri, 1994, 1995; Scruggs et al., 1993). These studies also indicated how special education teachers can support their learners during inquiry. For example, teacher-mediated discussions followed hands-on activities to facilitate meaning-making of such activities and tying activities to science content (Dalton et al., 1997). Extensive coaching by special education teachers has been shown to be essential to successfully scaffold instruction during inquiry-based activities and facilitate meaning-making of the activities (Mastropieri et al., 1997). Guided questioning by special education teachers allowed
students to construct meanings of experiences in an inquiry environment (McCarthy, 2005; Palincsar et al., 2000). In a sense, all these studies have repeatedly recognized the role of special education teachers in guiding students toward accomplishments in the inquiry labs.

In the years following federal mandates such as No Child Left Behind (2001) and increased support for students with disabilities (Individuals with Disabilities Education Act [IDEA], 2004), more research on inquiry instruction with learners with disabilities has appeared (Abels, 2014; Aydeniz, Cihak, Graham, & Retinger, 2012). Some of the studies revealed specific inquiry-based strategies that supported learners with disabilities in specific instructional settings (Abels, 2014). Only two studies, both published before NCLB (2001), addressed modifications of inquiry instruction (Canning, Wilson, & Lacy, 1997; Watson & Houtz, 1999), each indicating that inquiry instruction can be successfully modified for diverse learners in classrooms (Canning et al., 1997; Watson & Houtz, 1999). No study has explored preservice special education teachers’ learning about inquiry. Even if teaching students with disabilities is difficult to generalize due to the diversity in needs and settings (Rumrill et al., 2001), a general understanding of inquiry instruction could allow teachers to more effectively use inquiry in diverse K–12 educational settings.

**Inquiry in Science Teacher Preparation**

Preservice general science teachers learn about scientific inquiry in several ways during the science teacher preparation process (Abrams et al., 2007; Blanchard et al., 2010; Capps & Crawford, 2013; Crawford, 2014). While some opportunities arise from
inquiry-based science content courses that preservice science teachers take as non-science majors (Haefner & Zembal-Saul, 2004; Salter & Atkins, 2013), some opportunities arise from specialized platforms like professional development school-based internships (Crawford, 2007) or specialized science pedagogy courses (Tatar, 2012). Another potential method upon which preservice general science teachers learn about inquiry and inquiry instruction includes science methods courses that they take in the early stage of the science teacher education, typically before student teaching (Morey, Bezuk, & Chiero, 1997). Considering the science methods courses to be the closest to the present study’s context, I have closely examined several studies situated in the science methods course context.

**Learning About Inquiry in Science Methods Courses**

Being conscious of the lack of a universal definition for inquiry (Anderson, 2002; Abrams et al., 2007; Crawford, 2014; NRC, 2012), I wanted to examine what teacher educators considered to be scientific inquiry while they trained prospective science teachers about inquiry in science methods courses. Rather than examining only the outcomes of such learning from the preservice teachers’ perspective (examining preservice teachers’ knowledge or understanding of scientific inquiry), I used my methods-instructor lens to understand what opportunities received by preservice teachers in science methods courses to learn about scientific inquiry and inquiry instruction. I also paid close attention to what results came of these learning opportunities. The following studies provide key insights into this aspect of my research.
Plevyak (2007) considered using science process skills (i.e., observing, classifying, measuring, communicating, predicting, inferring and experimenting) in an NRC-aligned science methods course to be essential to learn about inquiry. In a study conducted with 52 early childhood education (PreK–3) majors enrolled in a 10-week-long science methods course, participants took part in several inquiry-based investigations as learners of science. Participants developed research questions that they wanted to investigate, proposed answers to their research questions and collected and analyzed data to support their answers using process skills. The course included a field trip to a zoo where participants used science process skills to draw inferences from observations. The course also allowed participants to experience inquiry as teachers of science. In this capacity, participants read about and discussed inquiry as a science teaching method, learned about the NSES’s recommendations and the Learning Cycle (Bybee, 2000) and developed lesson plans and assessments for science lessons using NSES’s recommendations and the Learning Cycle (Bybee, 2000).

Qualitative analysis of data indicates that following such experiences, participants became able to articulate how process skills may be used in science teaching and conducting scientific inquiry. Participants in this study also expressed how science instruction involving the use of process skills promoted understanding and engagement in science in elementary grade learners. Process skills generated authentic experiences that closely aligned with the NSES’s conceptualization on inquiry (Plevyak, 2007). Prospective early elementary science teachers in this course took the opportunity to learn
about inquiry by experiencing inquiry as learners as well as teachers of science in the science methods course.

In another study, Varma et al. (2009) considered an NRC-aligned science methods course and associated field experience to be a suitable platform to provide preservice elementary teachers with various inquiry learning opportunities. The studied science methods course first taught participants about the five essential features of inquiry (NRC, 2000) and then allowed participants to take part in multiple inquiry-based investigations thereafter. Participants, as learners of science, answered research questions using data collection and analysis. Participants, as teachers of science, learned about the role of five essential features of inquiry (NRC, 2000) and the Learning Cycle model (Bybee, 2000) in guiding instructional planning for inquiry lessons and developed lesson plans using the NSES recommendations and the Learning Cycle.

In addition, participants also held discussions concerning the use of guided inquiries versus lecture methods to teach science in elementary classrooms. Participants practiced developing scientifically-oriented questions to initiate student investigations and evaluated instructional materials for suitability to teach science using inquiry. This science methods course, similar to Plevyak’s (2007) study, allowed teacher candidates to learn about inquiry and inquiry instruction by experiencing it from the learners’ as well as the teachers’ point of view. Like Plevyak, Varma et al. (2009) found that learning about inquiry through various experiences helped preservice teachers to develop a better understanding of the five features (NRC, 2000). Participants could then articulate how NRC’s recommendations could be applied to their future teaching contexts and describe
how materials became more learner-centric using document’s guidelines. This study also reveals how preservice elementary teachers can be taught about scientific inquiry using the NRC’s conceptualization and experiencing these conceptualizations both as learners of science (engaging in scientific investigations using five features) as well as teachers of science (developing lesson plans along the NSES’s recommendations, the Learning Cycle, creating inquiry-based assessments and evaluating instructional materials for inquiry) in a methods class context.

More recently, Santau, Maerten-Riviera, Bovis, and Orend (2014) revealed that participation in inquiry-based investigations in the science methods course context not only supported preservice teachers’ learning about inquiry instruction, but that such experiences increased the science content knowledge of the study participants. Nineteen undergraduate early childhood education majors took a standards-aligned science content pretest prior to any teaching of science content or pedagogy. Following the pretest, participants engaged in twelve in-class inquiry investigations on various science topics during which they answered research questions using the NRC’s (2000) guidelines. Participants then developed lesson plans for selected inquiry investigations using a modified Learning Cycle (Bybee, 1997, 2000) and taught selected lessons to their peers in the methods class. Participants took a post-test on science content knowledge at the end of the semester. Quantitative analysis of the scores on pre- and post-tests indicated an increase in science content knowledge in the participants, which the researchers believed resulted from the method of teaching the course. Learning to teach science using an inquiry-based Learning Cycle model (Bybee, 1997, 2000) also allowed an in-
depth exploration of science concepts being taught using this extended pedagogy. As a result, participants’ science content knowledge increased. Santau et al. (2014) provided empirical support for learning about inquiry by experiencing inquiry as learners of science in a science methods class since such experiences enhanced learning about inquiry in participating preservice elementary science teachers.

Ucar and Trundle (2012) likewise found that preservice general science teachers increased their content knowledge when engaged in NRC-related inquiry experiences as learners of science. In this study, conducted with 96 elementary preservice teachers from three elementary science methods courses in Turkey, participants learned about the scientific concept of tides while being placed in either of the three instructional settings—traditional (teacher-centered, lecture-based with classroom discussion), traditional with simulation (visualizing tides in simulation video, followed by teacher-centered, lecture and classroom discussion) and inquiry-based with archived online data. While the methods instructor provided the research question on tides and suggested procedures for collecting and analyzing the data, participants collected and interpreted answers for themselves in the inquiry setting. Quantitative analysis of scores on science content knowledge of participants indicated that the participants receiving inquiry-based instruction with archived online data performed significantly better than the other two groups. Participants, as learners of science, not only performed inquiry activities, but their science content knowledge on science topics of the inquiry lessons increased following such instruction. Although conducted in a different educational setting and with preservice general science teachers, the Ucar and Trundle (2012) study informed
how preservice teachers can learn about inquiry by experiencing inquiry as learners of science in science methods courses.

In another study, Crawford, Zembal-Saul, Munford and Friedrichsen (2005) considered participation in inquiry-based investigations during science methods courses to be essential for learning about inquiry instruction. In the science methods course, preservice secondary science teachers learned about the scientific concept of evolution (in biology) using technology-supported inquiry instruction. The participants learned about evolution using a modified lesson of The Galapagos Finches (National Academy of Science [NAS], 1998), modified in the sense the participants used technology and software to collect and analyze data to answer their research questions. Even using a different platform (using software to collect and analyze data), participants still followed the NRC’s recommendations (NRC, 1996) and constructed scientific explanations by giving priority to evidence. Reflecting on such experiences, participants could identify the nature of scientific inquiry (Crawford et al., 2005). The study also revealed that learning about inquiry can occur in diverse educational settings, but experiencing inquiry as learners of science and reflecting on these experiences are fundamental to learning about inquiry for preservice science teachers.

Empirical studies also indicate that experiencing inquiry as learners alone may not be enough for preservice teachers to develop a strong inclination toward teaching using inquiry (Lustick, 2009). In a mixed methods study involving 15 graduate students from a graduate-level secondary science methods course, participants failed to connect their learning to their future science teaching despite participation in elaborate inquiry-based
science investigations (Lustick, 2009). Participants also remained resistant to practicing inquiry instruction in their future classrooms. In this study, 15 secondary science teachers enrolled in a master’s level science methods course participated in a nine-week-long inquiry investigation that involved answering the research question “How can peak autumn color in New England be determined?” Participants worked in small groups, planned their investigations, collected data for eight weeks, analyzed data, and shared their findings in class. A pre-assessment and post-assessment of participants’ experiences, knowledge, beliefs, and attitudes toward scientific inquiry were conducted before and after the inquiry project. Qualitative analysis of data including participants’ investigation protocols, reflection papers, and interviews indicated that although all could eventually answer the research question using data collection and analysis, the project did not support the development of an inclination toward using inquiry in the future.

Lustick (2009) suggested that the graduate student participants might have already had negative experience with inquiry prior to joining this program and thus did not fully appreciate the value of inquiry. Alternately, the lack of inclination toward inquiry instruction could also be due to an inadequate understanding of the inquiry instruction (Lustick, 2009). Whereas participants in this study gained in-depth experiences of scientific inquiry as learners of science, they did not get adequate experiences as teachers of science. Thus the participants could not apply their learning from the methods class to their future field teaching. Perhaps due to this lack of understanding, participants remained hesitant to confirm that they would use inquiry-based instruction in their future classrooms.
Although each of the above empirical studies indicates that experiencing inquiry as learners of science is an important aspect of training preservice teachers about inquiry, few empirical studies have focused on experiencing inquiry primarily from the teacher’s perspective. Davis (2006), for instance, found critiquing inquiry-based instructional materials can be useful to teach preservice science teachers about inquiry. In an NRC-aligned science methods course taken during the third semester of a four-year teacher education program, 20 elementary science teacher candidates were taught about the five essential features of inquiry (NRC, 2000) and then were prompted to develop criteria for critiquing inquiry-based instructional materials. Participants critiqued lesson plans and activities based on the NRC’s guidelines and evaluated to what extent these lesson plans allowed the use of the five essential features of inquiry (NRC, 2000). Qualitative analysis of data indicated that participants could add inquiry components to the science lessons that they critiqued. Participants identified opportunities for making predictions and observations and making sense of data to be important components in an inquiry-based lesson. They also considered planning and designing of inquiry investigations to be important aspects of teaching science using inquiry. Although the main goal of this study was to promote prospective elementary teachers’ productive use of instructional materials, the study did indicate that experiencing inquiry as teachers of science (developing and critiquing instructional materials for inquiry components) could be useful for teaching prospective teachers about inquiry instruction within science methods courses.
Another study conducted by Duncan, Pilitsis and Piegaro (2010) found training preservice teachers to successfully plan and deliver inquiry instruction to be an important experience for teaching preservice teachers about inquiry in a methods class context. In a qualitative study with 17 preservice secondary science teachers enrolled in two consecutive science methods courses, participants got the opportunities to design and critique inquiry instructional materials using the NRC’s (2000) guidelines for inquiry. The participants analyzed inquiry-based lesson plans based on the presence or absence of inquiry components and then revised lessons to make them more learner-centered (open). Participants improved in their abilities to critique inquiry-based materials and adapt science curriculum materials over the course of the study. There, inquiry experiences as teachers of science gathered during their preservice phase allowed preservice teachers to become more inquiry-oriented. Allowing participants to develop criteria for critiquing inquiry lessons and critiquing inquiry-based instructional materials based on those criteria enabled participants to perceive inquiry instruction as an engaging science teaching method. In that study, although adapting inquiry lessons mainly focused on the openness or student-centeredness of inquiry lessons in general and not address adaptations for diverse learners, these insights could be taken toward adaptations of inquiry instruction for diverse learners in science classrooms (Duncan et al., 2010).

**Summary**

Research indicates that the NRC’s (1996, 2000) conceptualizations of scientific inquiry are fundamental to training preservice general science teachers about inquiry instruction (Crawford et al., 2005; Davis, 2006; Duncan et al., 2010; Plevyak, 2007; Ucar
& Trundle, 2012; Varma et al., 2009). While an NRC-aligned science methods course allows preservice teachers to explore inquiry as learners of science (Crawford et al., 2005; Plevyak, 2007; Santau et al., 2014; Ucar & Trundle, 2012), these courses also often provide opportunities for preservice teachers to experience inquiry as teachers of science (Davis, 2006; Duncan et al., 2010; Plevyak, 2007; Varma et al., 2009). Many positive outcomes have been associated with such experiences, including the enhancement of science content knowledge, enhancement of knowledge about inquiry instruction and the development of a positive attitude toward inquiry instruction (Crawford et al., 2005; Davis, 2006; Duncan et al., 2010; Plevyak, 2007; Santau et al., 2014; Ucar & Trundle, 2012; Varma et al., 2009).

Preservice Teachers’ Enactments of Inquiry Instruction

While science methods courses have provided preservice teachers opportunities to learn about inquiry by experiencing inquiry as learners or teachers of science, these courses have also explored preservice general science teachers’ earliest opportunities to enact inquiry instruction. These teaching experiences either constituted teaching short inquiry lessons in front of their peers in science methods classes (microteaching) or teaching science lessons to K–12 learners in the field. I analyzed preservice science teachers’ enactment of inquiry instruction in both contexts. The following studies provide key insights in this regard.

Windschitl (2003) explored whether or not learning about inquiry instruction in a science methods course could be applied to future instruction in the field. In a qualitative study with preservice secondary science teachers selected from an NRC-aligned (NRC,
secondary science methods course, participants first learned about science as a way of knowing and as the process in which scientists build scientific knowledge during the first two weeks of the methods class. While the methods instructor did not provide any explicit definition of scientific inquiry, participants held discussions about science as a way of knowing and the construction of scientific knowledge. Following the discussions, candidates participated in a six-week-long open inquiry project on selected science topics. The projects remained open in the sense that participants first observed their local environment to develop research questions that they sought to investigate. Participants were then asked to design their investigations, collect and analyze data and defend the results in the class using a formal presentation. Some students also took the opportunity to teach a portion of their lesson in the methods class (microteaching) and receive feedback from their peers and methods class instructor. Participants revised their lesson plans according to the feedback received in the methods class and taught the lesson to their students during their field placements over the next nine weeks. Observations of participants’ teaching in the field and supporting artifacts were qualitatively analyzed to examine whether participants could bring what they had learned from their inquiry projects to the field placements. The researcher then interviewed participants about actual learning experiences gathered in the project as well as their field teaching experiences.

Windschitl (2003) found that participants with strong understandings of scientific inquiry could successfully apply learning from the inquiry projects in the methods class to teaching science lessons in the field. Participants with prior science research
experiences had stronger understandings of scientific inquiry. Moreover, the same candidates could more successfully use guided and open inquiry in their placement classrooms when compared to participants who held positive views about inquiry. Though conducted with secondary science teachers, the study indicated that understanding about inquiry as learners of science was essential to successfully teach science using inquiry. Further, the study revealed that experiences as learners of science can develop from experiences outside science methods courses and yet contribute to participants’ enactment of inquiry instruction during their teacher-preparation phase.

Experiences with inquiry or investigations outside science methods classes can also influence teacher’s beliefs and enactment despite their inquiry experiences inside science methods classes. In a qualitative study, Windschitl (2004) established that such outside experiences not only influenced beliefs about inquiry in preservice secondary science teachers, but these beliefs in turn influenced the enactment of inquiry instruction during methods class. In a multi-case study with 14 preservice secondary science teachers enrolled in a secondary science methods course, the course instructor first initiated a discussion about scientific inquiry and its role in generating and extending scientific knowledge. Participants then took part in science inquiry projects, where they developed research questions on various topics and then planned investigations to find answers to those questions using data collection and analysis. At the end of their inquiry projects, participants presented their inquiry projects to their peers and defended their results.
Qualitative interviews and artifacts collected from participants indicated that participants held a unique conception of “doing science,” and these conceptions influenced the way they interpreted inquiry instruction. While some of the participants’ practices appeared similar to the NRC’s version of inquiry, many held misconceptions about the fundamental aspects of science. These novice ideas about scientific inquiry, the “folk theories of inquiry” (Windschitl, 2004), arrived from experiences developed in contexts beyond their science teacher preparation. Some of these false beliefs about inquiry came from misconceptions in textbooks, media, and even other members of the science education community. The study recognizes the role of personal beliefs (arising from contexts beyond the methods classrooms) to influence preservice science teachers’ enactments of inquiry instruction.

Similar to Windschitl (2003, 2004), Hancock and Gallard (2004) discovered that teachers’ beliefs influenced the preservice secondary science teachers’ understandings of the role of teachers during inquiry instruction. In a qualitative case study conducted with five prospective secondary teachers selected from a secondary science methods course, participants had to draw a picture of themselves as science teachers and provide a written explanation of their drawing. They then were asked to draw a picture of someone learning science and provide a written explanation of the drawing. Qualitative analysis of the images, associated text and individual interviews revealed a dichotomy in participants’ understanding of role of teachers in inquiry environments. Participants’ beliefs about their roles as science teachers varied along two key dualities: learning through experience versus learning through transmission and student-centered versus teacher-centered
inquiry. While some participants depicted themselves as facilitators of experiential learning, others depicted themselves as the directors of lecture and laboratory activities. Laboratory activities may not necessarily be inquiry, since they may not involve answering research question by data collection and analysis (Blanchard et al., 2010; Schwab, 1962). Like earlier studies, this study also indicated that participants’ past experiences in science influenced certain beliefs about inquiry instruction, and these beliefs in turn influenced their conception of teachers’ roles in inquiry class. In this case, prior experience as learners of science influenced preservice teachers’ learning about inquiry instruction.

Crawford (2007) revealed that teaching using inquiry is a complex enterprise, and many factors influenced the enactment of inquiry. In a qualitative study with five preservice high school teachers, Crawford found that personal beliefs about science and science teaching influenced participants’ enactments of inquiry instruction more so than what participants learned during their teacher preparation phase. During a year-long internship in a professional development-based teacher education program, participants learned about inquiry using NRC’s (2000) guidelines. They then developed inquiry lessons that they intended to use in their placements. Participants received continuous feedback from their mentors, as well as their methods instructor, on the lesson plans. Qualitative analysis of data indicated that participants adopted a variety of strategies while teaching science using inquiry in the field. While their teaching ranged from traditional, lecture-based methods to innovative, open-inquiry approaches, both knowledge and personal beliefs about science and science teaching influenced their
science teaching practices. External factors like time and resources, as well as relationships with their mentor teachers and teachers’ knowledge and beliefs about inquiry, influenced these preservice science teachers’ enactment of inquiry instruction as well.

The absence of a learner-centered approach to inquiry instruction has been reported in preservice elementary science teachers during their initial field teaching. Leonard et al. (2009) analyzed inquiry instruction of eight prospective elementary teachers during their student teaching using the Science Teachers Inquiry Rubric (STIR) developed by Bodzin and Beerer (2003). The rubric examined the presence or absence of features of inquiry as outlined by the NRC’s (2000) conceptualization. Numerical analysis of scores assigned to the inquiry components based on their presence, absence, or variations indicated that participants’ enactment ranged from “cookbook” instruction to a moderate use of inquiry. The strongest support appeared for the idea that “learners give priority to evidence to draw conclusions and evaluate explanations” (p. 35), and the weakest support was found for the idea that “learners are engaged by scientifically-oriented questions” (p. 35), indicating that preservice teachers did not enact open inquiry during student teaching. This study further revealed that the enactment data did not correlate well with the science content knowledge of participants. This result is important because a lack of scientific content knowledge has been shown to hinder inquiry-based science teaching in elementary science teachers (Appleton, 2006; Nowicki, Sullivan-Watts, Shim, Young, & Pockalny, 2012). The participants’ science content knowledge was not a deciding factor for their ability to engage in learner-centered
inquiry (Leonard et al., 2009). The study did not provide any detailed insights as to why these results happened. Nevertheless, this study did identify that, like preservice secondary science teachers, elementary science teacher candidates struggled to incorporate learner-centered inquiry instruction into their initial lesson plans.

The problem with the enactment of inquiry instruction is reported in preservice elementary science teachers outside the U.S. as well. Yoon, Joung, and Kim (2012) conducted a qualitative study with 16 fourth-year preservice elementary teachers from a science methods course in South Korea. In this study, participants came up with science topics that they wanted to teach in their field placements, developed inquiry-based lesson plans around those topics, received detailed feedback on their lesson plans by the methods instructor and revised lessons according to the feedback before teaching students. Introspection into their enactment of inquiry-based teaching revealed struggles despite receiving feedback on their lesson plans in the methods class. Participants had difficulties developing children’s ideas and curiosity, guiding children to design scientifically-oriented experiments, scaffolding children’s data interpretation, and discussing the results of inquiry investigations. That study revealed that experiencing scientific inquiry as teachers of science alone might not be enough to prepare preservice teachers to enact inquiry instruction. Preservice teachers had the opportunity to learn about inquiry as teachers by developing and revising inquiry lessons, but they did not experience scientific inquiry as learners of science themselves, and as a result, failed to use inquiry instruction in their classrooms.
In a more recent study, Kang, Bianchini, and Kelly (2013) allowed preservice secondary teachers to learn about inquiry and the five features (NRC, 2000) in their science methods course and explicitly prompted participants to reflect on how they might apply what they had learned in their upcoming field teaching. The eight preservice secondary science teachers explored the role of biological toxins in a ten-week-long inquiry-based investigation. During the study, participants, as learners of science, engaged in inquiry investigations and answered research questions using data collection and analysis. These preservice teachers had the opportunity to revise their investigation protocols following initial analysis of results and presented their final results in front of their peers. Participants reflected on the inquiry project experiences and developed lesson plans they thought appropriate to teach future students. Participants taught a portion of the lesson in front of their peers, revised the lesson according to feedback received, and then taught their actual students using the modified lesson plans. While participants could relate their methods class experiences to their own science learning experiences (prior experiences as students of science), they still needed extensive support from teacher educators to transition more easily into their roles as science teachers. Engaging in multiple inquiry experiences and reflecting on these experiences both as learners and teachers of science allowed these student teachers to transition from learners of inquiry instruction to teachers of inquiry instruction in their actual classrooms (Kang et al., 2013).
Summary

Empirical literature suggests that preservice general science teachers *do* struggle with the enactment of inquiry instruction, many struggling with teaching using NRC guidelines (NRC, 2000) of inquiry. Despite support in a science methods course, teacher candidates often adhere to teacher-directed instruction and find it difficult to practice inquiry in the field (Crawford, 2007; Davis, 2006; Hancock & Gallard, 2004; Kang et al., 2013; Lustick, 2009; Plevyak, 2007; Windschitl, 2003, 2004; Yoon et al., 2012). Experiencing inquiry only as learners of science (Lustick, 2009), or only as teachers of science (Yoon et al., 2012) might not be enough to educate prospective science teachers about inquiry instruction. Teacher candidates struggle with their initial teaching using inquiry due to experiences gathered *inside* methods classes (Crawford, 2007; Plevyak, 2007) as well as *outside* methods classes (Crawford, 2007; Hancock & Gallard, 2004; Plevyak, 2007; Windschitl, 2003, 2004).

Preservice Teachers’ Views on Inquiry Instruction

A number of empirical studies indicate that preservice teachers largely perceive inquiry as a useful pedagogical tool that supports science learning in K–12 students. While learning about inquiry in methods courses preservice general science teachers held positive views such as inquiry supports understanding and engagement in science (Plevyak, 2007; Varma et al., 2009). Participants in methods classes have articulated how inquiry instruction allows learners to build scientific knowledge using evidence-based claims, how it increases content knowledge in students by facilitating understanding of content knowledge and how it is more engaging and enjoyable than
traditional lecture-oriented forms (Crawford et al., 2005; Davis, 2006; Duncan et al., 2010; Plevyak, 2007; Ucar & Trundle, 2012; Varma et al., 2009; Windschitl, 2003).

While expressing their views about scientific inquiry, preservice general science teachers also have identified some obstacles associated with inquiry instruction. While some of the concerns include logistic elements like lack of time and resources, cooperation from mentor teachers and challenging instructional setting (Crawford, 2007; Plevyak, 2007), other reasons include internal factors like a lack of content knowledge (Davis, 2004), the influence of beliefs about inquiry (Crawford, 2007; Windschitl, 2003, 2004) and difficulties translating inquiry learning into practice (Kang et al., 2013; Lustick, 2009; Yoon et al., 2012). As learning about inquiry through multiple experiences during methods classes have promoted positive attitudes about inquiry instruction (Plevyak, 2007; Varma et al., 2009; Windschitl, 2003), preservice teachers required the support from teacher educators to transition from learners to teachers of inquiry instruction (Kang et al., 2013).

**Science Teaching in Diverse Instructional Settings**

Despite increased demands for inclusive education, a variety of instructional settings for science teaching to learners with disabilities largely remains (Mastropieri & Scruggs, 2010; Rumrill, Cook, & Wiley, 2011). The existence of this variety of instructional settings is supported by empirical evidence. A survey study of science placements for children receiving special education revealed that while some schools provide inclusive settings, others provide diverse special education settings to teach science to special learners (Vannest et al., 2009). As many as 10 different combinations
of instructional settings have been reported for science instruction for special learners in one studied grade (fourth grade) in a single school district in Texas (Vannest et al., 2009). In another survey of 120 in-service secondary science teachers, Irving et al. (2007) found that no respondents had any training in special education, but they each did have students with disabilities placed in their science classrooms. All respondents indicated that they needed additional support for teaching science to learners with disabilities. These participants underwent almost 50 hours of professional development focused on teaching science to diverse learners using inquiry. Following this training, participants could successfully adapt science lessons for diverse learners in their inclusive classrooms. This kind of professional development, however, might not be available to preservice teachers whose actual classroom teaching experiences are at their beginning stages.

This diversity of instructional setting holds implications for both preservice general science teachers as well as preservice special education teachers, since both can be tasked with teaching science to diverse learners individually or in collaboration with their future placements (Vannest et al., 2009). Yet surprisingly, preservice teachers’ conceptions about teaching science to diverse learners appear only minimally in the current literature (Cobern & Loving, 2002).

In this next section, I revisit some of the studies conducted with preservice general science teachers in inclusive classrooms to highlight the lack of emphasis placed on teaching science to diverse learners. For example, in Plevyak’s (2007) study, following experiences in an NRC-aligned science methods course, participants applied their learning to teaching diverse learners in their placement classrooms. Halfway
through the course, participants started adapting inquiry lessons according to the specific needs present in the class and chose strategies that they felt best supported learners in the classroom (videos for visual learners, audio recording for oral learners). Even later in the methods course, participants began to question whether inquiry instruction could fit into teaching subjects other than science, indicating that inquiry enhanced critical thinking in all children across subjects. These insights had not been addressed in the discussion section.

Similarly, Davis (2006) claimed that adapting instructional materials is essential for teaching science to diverse learners, and here, adaptation meant being more learner-centered, not differentiating inquiry instruction for learners with diverse needs and abilities. Duncan et al.’s (2010) study, which considered training teachers to critique inquiry lessons to be important toward adapting inquiry-based instructional materials, did not provide any specific insights into how lessons may be adapted for diverse learners in the classrooms. Leonard et al.’s (2009) study indicated that the instructional setting is an important factor for influencing science teaching using inquiry and referred to diversity only in terms of the social stature of students (student demographics, economic status of parents) and not learners with diverse abilities. These previous studies marginally address how inquiry lessons must be adapted to fit diverse learners in the classroom. Additionally, the studies indicate that both general and special education teacher educators must help preservice teachers consider appropriate adaptations for learners with special needs.
Empirical studies indicate that preservice general education teachers sometimes feel unprepared to teach learners with disabilities in inclusive classrooms (Everhart, 2009; Gately & Hammer, 2005; Shippen et al., 2005). In an exploratory case study conducted with preservice secondary science teachers, Gately and Hammer (2005) found that preservice general science teachers believed themselves unable to meet the needs of learners with disabilities in an inclusive science classroom. The researchers further indicated that the teacher educators instructing the participants had little or no knowledge about teaching students with disabilities and thus failed to teach participants about adapting instructions for diverse learners in inclusive classrooms. These researchers recommended adding more instruction regarding teaching science to diverse learners to prospective teachers during their teacher preparation process.

In another study, though conducted with physical education majors, similar insights arose about teaching learners with disabilities in inclusive settings. Everhart (2009) reported anxiety in elementary physical education majors when it came to teaching learners with disabilities in an inclusive setting. Although participants recognized that instructional materials need to be adapted to best fit learners’ needs, participants realized that adaptation can be difficult to designed and implemented due to the variety in students’ needs and abilities. The study also recognized that an absence of any prior experience of teaching learners with disabilities created anxiety in participants. Everhart recommended teacher education programs to address teaching in diverse settings to future teacher candidates.
Shippen et al. (2005) provided similar recommendations where researchers surveyed teacher candidates’ levels of anxiety regarding teaching diverse students in inclusive classrooms before and after participation in a non-major, introductory special education course. Both general education teacher candidates and special education teacher candidates who took the course felt more comfortable teaching special needs students in inclusive settings. While this study did not indicate how many of the 149 general education candidates surveyed in the study were science education majors, when considering the increased demand for inclusive classrooms, it is quite possible that preservice science teachers will be assigned to teach in classrooms that have learners with diverse abilities. In such conditions, teachers could feel unprepared to teach science to these diverse learners.

While general science teachers may be worried about teaching science to learners with disabilities in inclusive classrooms (Everhart, 2009; Gately & Hammer, 2005; Irving et al., 2007; Shippen et al., 2005), special education teachers might feel less competent to deliver science content support to students with disabilities during science activities. In a qualitative study exploring science teaching in an inclusive high school science classroom, Moin et al. (2008) found that even with a special education teacher present in studied classrooms, students with learning disabilities did not receive adequate support to meet their needs in science activities. They recommended professional development for the co-teachers to help general science teachers as well as special education teachers understand their respective roles and sharing of teaching responsibilities. But the perception of co-teaching might be difficult among preservice teachers, as found in Arndt
and Liles’s (2010) study. These researchers found that participating preservice social studies teachers and special education teachers maintained their respective theoretical frameworks even while co-teaching. This disjointedness resulted in a separation of beliefs and perceptions about co-teaching. To address such problems, Arndt and Liles suggested general education-special education teacher partnerships during the teacher preparation phase. These partnerships could be practiced between preservice general science and preservice teachers so as to provide more awareness of each other’s educational frameworks.

**Summary**

An approach to teaching science using inquiry that also addresses the needs of diverse learners remains extremely rare. A significant diversity in instructional settings exists when it comes to teaching science to all learners, including learners with disabilities (Vannest et al., 2009). While preservice general science teachers might feel unprepared to teach science to special learners in an inclusive setting (Everhart, 2009; Gately & Hammer, 2005; Irving et al., 2007; Shippen et al., 2005), special education preservice teachers potentially have content struggles with teaching science to students (Moin et al., 2008). Keeping in mind the diversity of future settings as well as struggles found in preservice teachers, teacher educators of both fields should design teacher education programs to prepare teacher candidates to successfully teach science in diverse classrooms.
Chapter Summary: A Gap in Literature and Addressing That Gap

Inquiry and its five features (NRC, 2000) as encouraged by science education organization (AAAS, 1993; NRC, 1996, 2012, NSTA, 2004) have evidenced empirical support in K–12 settings (Abell, 1999; Bell et al., 2003; Blanchard et al., 2010; Gibson & Chase, 2002; Yager & Akçay, 2010). Despite a few conflicting versions in both general science (Cobern et al., 2010; Klahr & Nigam, 2004; Kirschner et al., 2006) and special education (Mastropieri et al., 1997; Scruggs & Mastropieri, 1994; Scruggs et al., 1993) contexts, several empirical studies reported positive outcomes of inquiry and five features (NRC, 2000) in diverse instructional settings (Crawford, 2014). Inquiry instruction occurs within a constructive environment (Anderson, 2002; Bybee, 2000) and may be particularly useful for learners with disabilities especially those who need stronger support from teachers to accomplish learning with the new science standards today (Scruggs, Brigham, & Mastropieri, 2013). For example, the new standards (NRC, 2012) not only put forward Science and Engineering Practices in which all students needed to engage, but also require students to integrate the disciplinary Core Ideas and interdisciplinary Crosscutting Concepts with Practices (NRC, 2012; NGSS Lead States, 2013). Learners with disabilities could need additional support from teachers in special education to make these connections successfully (Scruggs et al., 2013), and inquiry instruction allows students to pursue questions about science content at various degrees of difficulty with various degrees of support. Although a shift in the paradigm is evident in research from exploring what students with disabilities do in an inquiry environment (Dalton et al., 1997; Mastropieri & Scruggs, 1994; Mastropieri et al., 1997; McCarthy
2005; Melber & Brown, 2008; Palincsar et al., 2000; Schmidt et al., 2002; Scruggs & Mastropieri, 1994, 1995; Scruggs et al., 1993) to how learners with disabilities may be taught or may be supported using inquiry instruction (Abels, 2014; Aydeniz et al., 2012; Brigham, Scruggs, & Mastropieri, 2011), investigations on how special education teachers learn to deliver successful inquiry instruction are extremely rare. This study attempts to address this gap in the literature by investigating preservice special education teachers’ learning about inquiry.

An NRC-aligned (NRC, 2000) inquiry-based science methods course has been a successful platform upon which to teach preservice general science teachers about inquiry (Crawford et al., 2005; Davis, 2006; Duncan et al., 2010; Kang et al., 2013; Leonard et al., 2009; Plevyak, 2007; Santau et al., 2014; Ucar & Trundle, 2012; Varma et al., 2009; Windschitl, 2003, 2004). In these courses, participants experience inquiry as learners of science or as teachers of science and reflect on their experiences. While experiencing inquiry as learners of science (Lustick, 2009) or teachers of science (Yoon et al., 2012) alone might not be enough to teach preservice teachers about inquiry, experiencing inquiry as both as learners of science (Crawford et al., 2005; Kang et al., 2013; Plevyak, 2007; Santau et al., 2014; Ucar & Trundle, 2012; Varma et al., 2009; Windschitl, 2003, 2004), as well as teachers of science (Davis, 2006; Duncan et al., 2010; Kang et al., 2013; Plevyak, 2007; Santau et al., 2014; Varma et al., 2009; Windschitl, 2003, 2004) have promoted learning about inquiry and inquiry-based science teaching (Kang et al., 2013; Plevyak, 2007; Varma et al., 2009; Windschitl, 2003). Enacting inquiry instruction has been difficult for preservice general science teachers due to factors
arising from contexts inside or outside science methods classes (Crawford, 2007; Hancock & Gallard, 2004; Kang et al., 2013; Plevyak, 2007; Windschitl, 2003, 2004). These findings are extended to preservice teachers in special education, who also can guide their students to successful teaching by inquiry (Abels, 2014).

Special education teachers can teach science either individually or in collaboration with general science teachers in diverse instructional settings (Bouck, 2007; Irving et al., 2007; Vannest et al., 2009), and preservice general science teachers have reported increased anxiety about teaching science to diverse learners in inclusive classrooms (Everhart, 2009; Gately & Hammer, 2005; Irving et al., 2007; Shippen et al., 2005). Special education teachers sometimes struggled to teach science to students with disabilities in co-taught classrooms (Moin et al., 2008), but they have not been studied as to how they learn about inquiry. An NRC-guided (2000) inquiry learning experience, which has been previously successful in teaching preservice general science teachers about inquiry, is extended to preservice teachers in special education and details of their inquiry learning experience is studied in this project. To capture the special education teacher candidates’ inquiry learning experiences in detail, a qualitative, interpretive research methodology has been adopted for this study. The qualitative research extended along four constructs—understandings (in terms of definitions and characterizations of inquiry), enactments of inquiry instruction, views, and future plans for inquiry—as held by preservice special education teachers while learning about inquiry in an NRC-aligned science methods course. The next chapter describes the methodology employed in this research.
CHAPTER III
RESEARCH DESIGN

This chapter explains the research design and methodology that I adopted to examine preservice special education teachers’ understanding, enactments, views, and future intents of using inquiry instruction in science. This chapter is organized into two parts: the research design and the research methodology. Part 1, the research design, informs readers about the context in which the study takes place. In this part, I first introduce the participants of the study and then introduce the environment from which participants have been selected. This environment is a K–8 general science methods course in which all the participants were enrolled as students. To describe the environment in detail, I provide a brief overview of the course, outlining its placement in the university’s teacher education program and its basic structure. Next, I provide a detailed account of the inquiry experiences that are provided to the students in the course to support their learning about inquiry.

In part 2 of this chapter, the research methodology, I provide my rationale behind selecting a qualitative, interpretive research methodology for this project, explaining how the purpose and the research questions guided the selection process of such methodology. I then describe the data sources used in the study and data collection process. Next, I give an account of the data analysis procedures adopted for the study. After describing the data collection and data analysis process, I explain my dual role in the project (the researcher and the course instructor) and the strategies I employed to maintain this dual
role. I conclude this chapter by delineating the strategies that I adopted to ensure trustworthiness of this qualitative research.

Part 1: The Context—Special Education Majors in a General Science Methods Course

This study intended to examine preservice special education teachers’ understandings, enactments, views, and future plans of scientific inquiry. To do so, I recruited special education teacher candidates enrolled in an inquiry-based K–8 general science methods course and examined their inquiry experiences and perspectives as gathered in the course using qualitative methods. The details of the study participants and the course follow.

The Participants

Participants in this study consisted of graduate and undergraduate majors in Special Education, enrolled in a K–8 general science methods course in a mid-size public university in U.S.A. In total, 34 special education teacher candidates from four special education concentration areas: Mild to Moderate Educational Needs, Moderate to Intensive Educational Needs, Early Childhood Intervention, and Deaf Education, were invited to participate in the study. From this initial pool, a total of 17 candidates from the first three concentrations (Mild to Moderate Educational Needs, Moderate to Intensive Educational Needs and Early Childhood Intervention) agreed to participate. Like any other student in the course, these participants completed all the assignments for the course but were also asked to participate in a face-to-face interview at the end of the course exclusively for the purpose of the study. One participant could not attend this
interview, and her data were not included in the data analysis. The gender, academic standing and special education concentration areas for the 16 candidates who contributed to this study are provided in Table 1.

Table 1

*Participant Details*

<table>
<thead>
<tr>
<th>No</th>
<th>Pseudonym</th>
<th>Gender</th>
<th>Academic Standing</th>
<th>special education concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Adam</td>
<td>M</td>
<td>B.Ed. (Junior)</td>
<td>MM-LAR</td>
</tr>
<tr>
<td>2.</td>
<td>Brian</td>
<td>M</td>
<td>B.Ed. (Senior)</td>
<td>MM-LAR</td>
</tr>
<tr>
<td>3.</td>
<td>Carol</td>
<td>F</td>
<td>B.Ed. (Junior)</td>
<td>MM</td>
</tr>
<tr>
<td>4.</td>
<td>Debra</td>
<td>F</td>
<td>B.Ed. (Junior)</td>
<td>MM</td>
</tr>
<tr>
<td>5.</td>
<td>Emily</td>
<td>F</td>
<td>B.Ed. (Senior)</td>
<td>MM</td>
</tr>
<tr>
<td>6.</td>
<td>Francine</td>
<td>F</td>
<td>B.Ed. (Senior)</td>
<td>MM</td>
</tr>
<tr>
<td>7.</td>
<td>Gail</td>
<td>F</td>
<td>B.Ed. (Senior)</td>
<td>MM</td>
</tr>
<tr>
<td>8.</td>
<td>Holly</td>
<td>F</td>
<td>M. Ed. (Graduate)</td>
<td>MM</td>
</tr>
<tr>
<td>9.</td>
<td>Ida</td>
<td>F</td>
<td>M. Ed. (Graduate)</td>
<td>MM</td>
</tr>
<tr>
<td>10.</td>
<td>Jack</td>
<td>M</td>
<td>M. Ed. (Graduate)</td>
<td>MM</td>
</tr>
<tr>
<td>11.</td>
<td>Kim</td>
<td>F</td>
<td>B.Ed. (Junior)</td>
<td>MI</td>
</tr>
<tr>
<td>12.</td>
<td>Luke</td>
<td>M</td>
<td>B.Ed. (Junior)</td>
<td>MI</td>
</tr>
<tr>
<td>13.</td>
<td>Mike</td>
<td>M</td>
<td>B.Ed. (Senior)</td>
<td>MI</td>
</tr>
<tr>
<td>14.</td>
<td>Nancy</td>
<td>F</td>
<td>B.Ed. (Senior)</td>
<td>MI</td>
</tr>
<tr>
<td>15.</td>
<td>Olivia</td>
<td>F</td>
<td>M. Ed. (Graduate)</td>
<td>ECI</td>
</tr>
<tr>
<td>16.</td>
<td>Paula</td>
<td>F</td>
<td>M. Ed. (Graduate)</td>
<td>ECI</td>
</tr>
</tbody>
</table>


The participating special education teacher candidates did not have any formal background in science, and all except one participant (Holly) have previously taken at
least one introductory-level science course in college. Holly had an art and tele-
production background and so did not take any science course before. In comparison,
Olivia, a graduate Early Childhood Intervention major, had taken several college-level
science courses (in biology and chemistry) during her undergraduate studies in Nutrition
prior to joining this program. Neither graduate nor undergraduate participants have any
prior teaching experience in science, but they had some experience with teaching children
in some capacity (such as tutoring, day care instructor, summer camp instructor). Many
of them had some experience working with students with disabilities (field observation,
working as a special education teacher’s aide, resource room observations, volunteering
in special education classrooms, etc.).

The Course

The course *Teaching Science in Early and Middle Grades* was a full-time,
classroom-based, 15-week-long course offered by the Department of Curriculum and
Instruction at a mid-size U.S. public university. Students met once a week for three hours
in a regular classroom setting. The science methods course is placed in either the fifth or
sixth semester in a four-year special education teacher education program at the
university and is offered during the semester when students also take a math methods
and/or a social studies methods course. The course is a requirement for the Mild to
Moderate Educational Needs majors and Early Childhood Intervention majors but was
optional for Moderate to Intense Needs majors and Deaf Education majors.

This course, as a K–8 general science methods course, had an objective to provide
teachers with meaningful and practical learning experience that will prepare preservice
teachers to create effective science learning environments for future K–8 students. Thus, although taken by special education teacher candidates, the course was a general science methods course, designed for preparing teachers to teach science in general K–8 classrooms and not teach methods in special education. This distinction appeared in the course syllabus and was also explicitly addressed by the methods instructor (me) in the first class. More information on the course follows and a complete syllabus can be found in Appendix A.

**Detailed Structure of the Course**

The curriculum of the course was developed based on the vision of science teaching in K–12 classrooms as held by the National Research Council (NRC, 1996, 2000, 2012) and supported by established efforts of methods instructors to prepare general science teachers to teach using inquiry instruction (Crawford et al., 2005; Davis, 2006; Duncan et al., 2010; Kang et al., 2013; Kim & King, 2012; Leonard et al., 2009; Lustick, 2009; Plevyak, 2007; Santau et al., 2014; Ucar & Trundle, 2012; Varma et al., 2009; Windschitl, 2003, 2004; Yoon et al., 2012). The design of the methods course enabled prospective science teachers to learn about scientific inquiry by direct, authentic experiences. Such experiences occurred in three platforms provided in the course: (a) experiencing scientific inquiry as learners of science; (b) experiencing inquiry as teachers of science; and (c) reflecting on such experiences.

The schedule of the course went as follows. All students had to complete an open-ended pre-questionnaire on the first day of the course. The pre-questionnaire obtained background information about the students including their academic standing,
special education concentration areas, previous science experiences, views on the significance of science teaching in their career, and preparedness to teach science at that time. In the first two weeks, students received the opportunity to explicitly learn about scientific inquiry and its features (NRC, 2000) and discussed how these components contributed to the development of scientific knowledge. Because no single definition of inquiry is accepted among the science education community (Anderson, 2002; Crawford, 2014), the course presented multiple versions of inquiry present within the field. Students learned about various conceptualizations of inquiry described by the National Research Council (NRC), the National Science Education Standards (NSES; NRC, 1996), the five essential features of scientific inquiry (NRC, 2000), the Science and Engineering Practices in the new framework (NRC, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013).

Following discussions on those concepts, students observed several Discrepant Events (Wright & Govindarajan, 1995) at activity stations set up in the classroom. Discrepant Events are in-class science activities that introduce science concepts by specific hands-on explorations and reasoning. Teachers assess students’ initial ideas, then set up and demonstrate the discrepancy, allow students to investigate the discrepancy, resolve the discrepancy, and assess for students’ changed ideas. With the in-class discrepant events, students answered a generic question, “Why do you think this is happening?” Students in small groups proposed answers to the question, conducted small investigations to explore possible answers, and developed and shared their explanations with their peers in terms of the evidence that they collected and analyzed. I
first allowed students to work on these inquiry investigations on their own but had to provide additional scaffolding (e.g., provided the procedures) to help students complete their investigations. Following the sharing of results, I debriefed the science content behind the activities and then debriefed the science pedagogy behind such activities, discussing how students, as learners of science, used the five essential features of inquiry (NRC, 2000) to answer their inquiry questions. Students then reflected on their experiences and discussed how these features allowed learners to develop scientific knowledge. Finally, students engaged in reflecting on these experiences as teachers of science, discussing how science teachers may use the five feature framework (NRC, 2000) to guide K–8 students’ inquiry investigations.

In the first two weeks, students also experienced three de-contextualized nature of science activities (such as the Mystery Cubes, Mystery Tube, and Tricky Tracks) as developed by the National Academy of Science (NAS, 1998) and discussed how these activities used the five essential features of inquiry (NRC, 2000). The inquiry classification article by Bell, Smetana, and Binns. (2005) was given as a pre-class assignment that students had to read before class. Students discussed the pros and cons of each level as teachers of science. At the end of class, students also wrote down their reflective responses on anonymous exit slips.

In the following weeks, a similar pattern followed with other topics (Conceptual Change, Learning Cycle, Safety in Science Classrooms, Science Standards, Reforming Cookbook Labs, Creative Assessments in Science and Adapting Science Teaching for Diverse Learners). Each week, the selected topic started with a discussion of the pre-
class reading assignment, followed by a brief PowerPoint on the topic and short inquiry-based activities that enabled students to experience the topic as learners of science. Most of the hands-on explorations were conducted with five essential features of inquiry (NRC, 2000) as a framework where students had to answer research questions through data collection and analysis. During each class, students shared the results of their inquiry investigations and defended their findings, giving priority to the evidence they had collected. Following each hands-on exploration, students were debriefed about the science content behind the activity by the methods instructor to understand the inquiry-based pedagogical approach associated with the activity. Students then reflected on the experiences, first as learners of science and then as future science teachers. They also discussed whether these lessons would work with students with disabilities and how they could adapt these lessons or methods to special education contexts. Each class ended with this reflective stance and exit slips.

The course contained two teaching assignments that enabled prospective teachers to enact inquiry instruction in front of their peers as teachers of science. Students were given two opportunities to teach science using inquiry instruction in microteaching assignments. Microteachings were short (20-minute) taped teaching presentations conducted in science methods class. Students also wrote reflection papers based on these videos. Microteaching assignments have been widely considered a crucial part of science teacher preparation, as these assignments allow preservice general science teachers to plan and deliver inquiry instruction, practice their teaching in front of their peers, observe their own teaching on videotape, and receive systematic feedback prior to the student

Microteaching assignments have been further used to prepare prospective general science
teachers to teach science using inquiry instruction (Plevyak, 2007; Santau et al., 2014;
Varma et al., 2009; Windschitl, 2003, 2004). In this course, two such teaching
opportunities were provided to special education teacher candidates. The first
microteaching took place halfway through the course (7th and 8th week into the semester)
and had to use a Discrepant Event to teach science to K–8 learners. The second
microteaching assignment took place during the last two weeks of the semester (14th and
15th week into the semester), and students had to demonstrate an understanding of the
five essential features of inquiry (NRC, 2000).

For each of the microteaching assignments, each student teamed up with a partner,
developed a lesson plan, and taught the lesson to their peers. Although students worked
in pairs on the planning and teaching of the lesson, their reflection papers took place as
individual assignments. Students could obtain ideas from other sources (such as science
books or the Internet) but still had to plan and deliver their instruction according to the
requirements of the assignment, making sure to cite their sources. Students had to
organize their inquiry instructional sequence according to the components of the
Learning Cycle (Bybee, 2000) and demonstrate their understanding of five features of
inquiry (NRC, 2000) in their teaching. I gave them a template for the lesson plan that
included components such as the grade, topic, standards, materials needed, instructional
sequence, assessments, classroom safety, adaptation strategies for diverse learners, and a
reference section. The template was not mandatory, but rather provided assistance to
preservice teachers who had limited prior lesson planning experience. The template, being optional, still allowed students to explore other lesson planning formats. Students submitted their lesson plans the day they taught, their microteachings were video-recorded, and teaching videos were returned to them at the end of the class. Students had one week from the return of their videos to watch them and write a reflection paper on their microteaching. For their inquiry-based microteaching, in addition to their lesson plan, each pair submitted a planning commentary describing the rationale behind their instructional planning. Though the instructional setting was not a component in the lesson plans, the lesson plan included adaptations for diverse learners.

After experiencing inquiry as learners and teachers of science, students reflected on their experiences both as learners and teachers of science. These reflection opportunities came either as formal assignments (reflection papers, reading reflections, planning commentaries, and questionnaires) or informal assignments (such as in-class discussions, debates, think-pair and share, creating concept maps, and draw-your-thoughts) and were embedded throughout the course. The reflection component encouraged participants to make sense of these inquiry experiences first as learners and teachers of science, and then as special education teachers who might teach science in future settings. I informed each student about the diversity in instructional settings for teaching science to diverse learners and informed them that it was quite possible that preservice special education teachers will end up teaching science to K–12 learners, with or without disabilities, individually or in collaboration in their future placements. The students took in-class, open-notes Midterms and Final Exams containing objective-type
multiple choice questions, short-answer questions, and essay-type questions. In addition, each student completed an open-ended post-questionnaire on the last day of the course that contained similar prompts as the pre-questionnaire.

Part II: Research Methodology

This study adopted a qualitative methodology. Both the purpose and the research questions of the study guided the data collection process and data analysis.

Rationale for Adopting a Qualitative Methodology

As with any other valid, scientific research (Creswell, 2007; Rumrill et al., 2011), the purpose and research questions guided the methodology selection for this qualitative research (Creswell, 2007; Merriam, 2009). The rationale behind such selection is described next.

Purpose of the research leading to selection of methodology. The general science methods course as described before gave an opportunity to all students to learn about inquiry instruction by experiencing inquiry as learners and teachers of science and then reflecting on such experiences. As a methods instructor, I believed in the vision of NRC (2000) that inquiry can support learning in all students, including students with disabilities. Although there is a lack of research on science teaching with students in special education (Courtade et al., 2007; McGinnis & Kahn, 2014; Therrien et al., 2011), let alone inquiry, I believed that special education teachers, if taught about inquiry, can support their students who may need considerable guidance from teachers which is crucial to accomplish science learning using the new standards today (Scruggs et al., 2013). In order to provide such guidance, sound knowledge of inquiry pedagogy was
necessary (Crawford, 2014). Proceeding with such thinking and drawing from existing research in both science and special education, I gave my students multiple opportunities to experience inquiry as learners and teachers of science and allowed them to reflect on these experiences so they might develop their own understanding of inquiry. Specifically, I provided students with multiple assignments to experience the five essential features of inquiry (NRC, 2000) as learners and teachers of science considering it to have strong empirical support. As a researcher, I grew interested in uncovering the meanings that the participants attributed to their inquiry learning experiences and employed qualitative methods (Hatch, 2002; Merriam, 2009) to study their interpretations in detail. Since qualitative research explores a phenomenon through the lived experiences of participants (Merriam, 2009), I employed a qualitative research methodology to capture participant’s inquiry learning experiences as occurring in the science methods class.

**Research questions leading to selection of methodology.** The four constructs that aimed to capture participant’s inquiry learning experiences consisted of their understandings (as captured by their own description of *what inquiry is* and *how inquiry is done*), their own enactments of inquiry instruction, their views on inquiry, and their future plans for using inquiry. Since inquiry lacked in both definition (meaning of *what inquiry is*) and characterization (*how inquiry is done*; Anderson, 2002; Crawford, 2014) and can be taught and learned in a variety of ways, participants’ own expressions of these constructs were considered to reflect what they considered as inquiry. Being taught to use inquiry with their students, I wanted to explore in detail how they taught using inquiry and the features (NRC, 2000) as teachers of science while they were learning
about it in methods classes. I wanted to extend this investigation into what they think about inquiry now (from their views) and how they want to extend their understandings to future teaching (their future plans). Given that inquiry and the NRC (2000) has been highly encouraged (NRC, 1996, 2000; NSTA, 2004) and seen strong empirical support (Crawford, 2014), I wanted to explore participants’ interpretation of inquiry, the participants who could teach science in a variety of future instructional setting (Arndt & Liles, 2010; Bouck, 2007; Vannest et al., 2009). Thus the four research questions guiding the dissertation called for an in-depth analysis of experiences in participants (Merriam, 2009). The participants, in this case, represented a group of teachers whose inquiry conceptions have not been previously reported and who come from different educational backgrounds and experiences than general science teacher candidates (Osgood, 2007; Rumrill et al., 2001) can attribute unique meanings inquiry that could be captured in detail via a qualitative study. For this reason, I chose a qualitative research methodology for this study.

As listed below, the four research questions guided this qualitative research project were:

1. How do preservice special education teachers define and characterize scientific inquiry in a general science methods class?

2. How do preservice special education teachers enact their inquiry instruction in the context of a science methods course?

3. What are these preservice special education teachers’ views on teaching using scientific inquiry?
4. To what extent do preservice special education teachers plan to incorporate inquiry instruction in their future science classrooms?
   a. What reasons do they offer to explain their inquiry inclusion decisions?
   b. For those who intend to incorporate inquiry instruction in their future teaching, how do they envision utilizing this method?

**Data Sources and Data Collection Process**

To comprehend preservice special education teachers’ understandings, enactments, views, and future plans for inquiry in science developed, I collected qualitative data from multiple sources that represented the participants’ own actions and voices (Merriam, 2009). These sources not only allowed me to provide rich, descriptive information about participants’ thinking and actions towards inquiry (Merriam, 2009), but they also assisted me to triangulate and cross-verify emerging themes (Hatch, 2002; Merriam, 2009). I collected data from four major sources of qualitative data: interviews, questionnaires, observations and supporting documents. These major sources for data are as described as follows.

**Interviews.** I interviewed each of the participants on their inquiry experiences in the science methods class. Semi-structured interviews (Merriam, 2009) lasted approximately an hour each and took place at the end of the course. These interviews contained open-ended questions that enabled participants to explain their perspectives about their inquiry experiences in the class. Being semi-structured in nature, these interviews allowed in-depth elaboration of views and responses from the participants, but at the same time were pragmatically designed to meet research needs (Hatch, 2002).
They allowed a certain level of flexibility that helped me as a researcher to collect information that can be analyzed to develop a deeper understanding of the participants’ experiences while staying focused on the main objective of the study (Merriam, 2009). In an effort to provide participants with a comfortable environment, the interviews took place at the department’s Instructional Resource Center and not inside the classroom. Interview questions gleans information pertaining to all four areas of my research questions. Questions asked participants about how they defined (described what inquiry is) and characterized inquiry (described how inquiry is done), how they felt about their own inquiry instruction, what views they held about inquiry instruction and what plans they had about using inquiry in their future science teaching. Interviews were audio recorded and transcribed verbatim, and participants were given pseudonyms in the transcripts. The interviews can be considered the primary source of data in this project since they contained participants’ direct responses on all four constructs that guided the research (understandings, enactments, views and future plans of using inquiry instruction in science). A complete interview protocol appears in Appendix B.

**Observations.** My second source of data was a record of participants’ interactions in the classroom. Being the instructor for the course, I observed the participants for 12 weeks (no observation on Midterm day, review week, and Final Exam day) and recorded memos about how they participated in various inquiry-based activities as learners of science, taught using inquiry instruction as teachers of science, and voiced their reflection on such experiences. Following each class, I reflected on how that day contributed to the research. I included specific moments to represent how certain
participants reacted in class that may inform my data analysis. I took note of the themes that appeared in the post-activity discussions, what questions the participants asked during the discussions, and who asked them. I also recorded any opposing views that appeared during classroom debates.

**Supporting documents.** I collected a number of class assignments from the participants as supporting documents (Merriam, 2009) toward this qualitative study. These documents, being already present within the research situation, provided valuable information and yet were unobtrusive in nature (Hatch, 2002; Merriam, 2009). The following items were collected as artifacts in the study.

- **Inquiry Microteaching Videos.** In this course, one major class assignment was the teaching of a short 20-minute K–8 lesson in science using the five essential features of inquiry (NRC, 2000). Participants paired up with a partner to develop a lesson plan and teach a portion of the lesson (mainly the engagement and exploration part of the lessons) to their peers. Since the assignment required each student to demonstrate his or her understanding of five features of inquiry, these videos had evidence of participants’ actual enactments of inquiry instruction. For this reason, I collected participants’ inquiry-based microteaching videos as visual documents (Merriam, 2009) in this qualitative study.

- **Inquiry Lesson Plans.** For the inquiry microteaching assignment, participants submitted a lesson plan that detailed their planning and delivery of their inquiry instruction. Students used a template for the lesson plan that included
the following components: grade, topic, standards, materials needed, instructional sequence, assessments, addressing classroom safety, adaptation strategies for diverse learners and references. It should be recalled that students could obtain ideas from a secondary source, such as a science book or the internet, but they still had to adapt their inquiry lesson plan according to the NRC-aligned guidelines established in their syllabus. These inquiry microteaching lesson plans provided evidence for how participants planned for delivery of inquiry instruction as teachers of science and thus were collected as supporting documents (Merriam, 2009) for the qualitative study.

- **Inquiry Microteaching Planning Commentaries.** All students had to submit a descriptive commentary about their planning for the inquiry-based microteaching instruction. In the planning commentary, students were required to write a summary of their selected teaching strategies/activities for their inquiry-based microteaching assignment and provide a rationale for their selection. The format for the planning commentary remained flexible, allowing students to freely illustrate their thinking behind selecting certain strategies/activities for their inquiry-based teaching. Considering this document as providing rich information on participants’ planning for inquiry instruction as future science teachers, I collected these planning commentaries as supporting documents in the study.

- **Inquiry Microteaching Reflection Papers.** I videotaped each student’s inquiry microteaching, which I returned to them at the end of class. Students
had one week to observe their own inquiry teaching videos and then write a reflection paper on it. Considering that these reflection papers contain evidence for participants’ own analysis of their own inquiry instruction, I collected them as existing documents that added to the richness of the qualitative study. Some of the prompts in the reflection paper consisted of:

How was my overall teaching experience? How many questions did I ask? What level of inquiry did I use? What would I do to improve this lesson and my teaching in general in the future? A full description of the reflection paper can be found in the syllabus of the course.

• **Pre- and post-course questionnaires.** As a part of the course assignment, each student had to complete two short questionnaires—one before and one after the course. The pre-questionnaire obtained background information about the students, including their academic standing, special education concentration areas subjects they like to teach, previous science experiences, perceptions about the significance of science teaching and their career and preparedness to teach science at that time. Some of the questions in the pre-questionnaire were: How has been your science learning experience so far? Have you heard about Inquiry or Scientific Inquiry? As a special education major, how important do you think science teaching will be for your future job? The post-questionnaires had similar questions and were collected at the end of the methods class. The terms “pre-” and “post-” should not be confused with establishing any cause and effect relationship but have been
added to the questionnaire to inform readers about the time of their collection.

Considering that the questionnaires can reflect any change in participants’ perceptions on inquiry over the course of study and still hold authentic responses (these had completion-only points), I collected them as supporting documents in this study. A full protocol for the pre- and post-questionnaires can be found in Appendix C.

**Data Analysis**

The study used a qualitative, interpretive approach to analyze the data collected from multiple sources as indicated above.

**Overall approach.** I used both a theoretically-imposed framework (specifically, NRC’s five essential features vision of inquiry; NRC, 2000) and qualitative open coding procedures (Strauss & Corbin, 1990) to analyze the data. Both analytic approaches came into use at different stages of analysis and with different purposes. Instead of starting with verifying presence or absence of theoretical insights, I began with open coding of data, first analyzing what meaning appeared in the code. For example, instead of simply verifying the presence or absence of a specific *NRC feature* (theoretical code) in a data piece, I focused on *what about the feature* (my open code) was being represented by that data piece whenever present, enabling me to interpret the meanings held by the participants themselves *before* examining the data through the theoretical NRC (2000) framework.

For each research question, I started with a line-by-line open coding (Charmaz, 2006), highlighting every few words that provided me with a conceptual meaning, and I
then entered them in a Microsoft Excel spreadsheet (hence referred to as the code document) as a unique code. Following Charmaz’s insights, codes were short and simple, yet conveyed certain meanings toward answering my research question. All the codes were substantive in nature at this point of analysis, that is, they came directly from the respondents, and did not include any theoretical stance or researchers’ insights. In sum, most of the codes were “in-vivo” codes (Charmaz, 2006). For instance, when a participant said, “inquiry is a teaching method,” “INQUIRY IS A TEACHING METHOD” was entered in the code document as an individual code. I performed open coding of data from various data sources, constantly comparing them against each other and adding new codes to the existing code list. I reviewed open coded data using analytical questions such as “What is the main idea of this code?” or “What is this code about?” and started assigning conceptual labels, constantly comparing them against each other and grouping them based on similarities (Charmaz, 2006; Merriam, 2009).

Establishing all the open codes from all the data sources, I proceeded to focused coding where I compared the open codes with the five essential features of inquiry (NRC, 2000). In doing so, I asked analytical questions such as, “Is this code representing an NRC (2000) feature?” and if yes, proceeded to analyzing, “What about the NRC (2000) feature is represented by the code?” The NRC (2000) features served as “points of departure” (Charmaz, 2006, p. 17) for my qualitative data, rather than representing the end themes. I paid close attention to the contexts in which these themes appeared, that is, if themes referenced general science learners, learners with disabilities, or both and color-coded the themes according to these three contexts.
Following focused coding, I implemented axial coding (Strauss & Corbin, 1990), and examined the four constructs (understandings, enactments, views, and plans) against each other. This execution established any relationship among the four constructs that can be revealed from patterns emerging from my data (Charmaz, 2006; Strauss & Corbin, 1990). I compared focused codes of understandings to focused codes of enactments, views, and plans to establish patterns across the four aspects of inquiry as studied in this qualitative research. In one example, the code *own science learning experience* appeared in *understandings* and *views*. Hence, *own science learning experience influencing understanding and views* emerged as a code following axial coding (Strauss & Corbin, 1990).

Finally, I brought in my theoretical knowledge (stemming from my own doctoral coursework and insights from the literature review) to develop result statements from my final codes. This final layer of comparison added theoretical sensitivity (Strauss & Corbin, 1990) to the axially-coded data and assisted me to develop the final result statements. Details of the final codes with emergent codes and theoretical codes as developed from my data analysis can be found in Appendix D. More specific details of data analysis as conducted using this approach follow.

**Data analysis for Research Question 1.** The first research question examined how preservice special education teachers defined and characterized scientific inquiry in a science methods course. Their definitions explored participants’ description of *what inquiry is* and characterization included description of *how inquiry is done*. I collected data from the pre- and post-questionnaires, inquiry microteaching videos, inquiry
microteaching lesson plans, inquiry microteaching reflection papers, inquiry microteaching planning commentaries, and post-course interviews.

I started data analysis by reviewing the interview transcripts, which included participants’ own articulation of what inquiry is (defining inquiry) and how inquiry is done (characterization of inquiry). I first coded transcripts using open coding (Strauss & Corbin, 1990), after which I open-coded other data sources such as participants’ inquiry lesson plans, planning commentaries, reflection papers, and questionnaires. I constantly compared them against each other and adding new open codes to the code list. Upon establishing all open codes, I proceeded to focused coding (Charmaz, 2006), revisiting the open code and comparing it to NRC (2000) image of inquiry. I specifically focused on participants’ articulation of what inquiry is, how inquiry is done and role of teachers and students during inquiry. I found participants’ understanding to reveal both matches and mismatches against NRC’s (2000) version of inquiry and participants to define and characterize inquiry both from the learner’s perspective as well as the teacher’s perspective. A full list of the final codes on participant’s understanding of inquiry can be located in Appendix D with exemplars from data.

**Data analysis for Research Question 2.** The second research question analyzed how preservice special education teachers enacted inquiry instruction in the context of a science methods course. For this research question, I first examined participants’ inquiry microteaching videos, comparing their enactments against the variations of five features (NRC, 2000) as described in by the NRC (2000; see Table 2).
Table 2

Variations in Five Essential Features of Inquiry (Adapted from NRC, 2000, p. 29)

<table>
<thead>
<tr>
<th>Features</th>
<th>Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Learner engages in scientifically-oriented questions</td>
<td>Learner poses a question</td>
</tr>
<tr>
<td></td>
<td>Learner selects among questions, poses new questions</td>
</tr>
<tr>
<td></td>
<td>Learner sharpens or clarifies question provided by teacher, materials, or other source</td>
</tr>
<tr>
<td></td>
<td>Learner engages in question provided by teacher, materials, or other source</td>
</tr>
<tr>
<td>2. Learner gives priority to evidence in responding to questions</td>
<td>Learner determines what constitutes evidence and collects it</td>
</tr>
<tr>
<td></td>
<td>Learner directed to collect certain data</td>
</tr>
<tr>
<td></td>
<td>Learner given data and asked to analyze</td>
</tr>
<tr>
<td></td>
<td>Learner given data and told how to analyze</td>
</tr>
<tr>
<td>3. Learner formulates explanations from evidence</td>
<td>Learner formulates explanation after summarizing evidence</td>
</tr>
<tr>
<td></td>
<td>Learner guided in process of formulating explanations from evidence</td>
</tr>
<tr>
<td></td>
<td>Learner given possible ways to use evidence to formulate explanation</td>
</tr>
<tr>
<td></td>
<td>Learner provided with evidence and how to use evidence to formulate explanation</td>
</tr>
<tr>
<td>4. Learner connects explanations to scientific knowledge</td>
<td>Learner independently examines other resources and forms the links to explanations</td>
</tr>
<tr>
<td></td>
<td>Learner directed toward areas and sources of scientific knowledge</td>
</tr>
<tr>
<td></td>
<td>Learner given possible connections</td>
</tr>
<tr>
<td>5. Learner communicates and justifies explanations</td>
<td>Learner forms reasonable and logical argument to communicate explanations</td>
</tr>
<tr>
<td></td>
<td>Learner coached in development of communication</td>
</tr>
<tr>
<td></td>
<td>Learner provided broad guidelines to use sharpen communication</td>
</tr>
<tr>
<td></td>
<td>Learner given steps and procedures for communication</td>
</tr>
</tbody>
</table>

Keeping in mind the variation along the teacher-learner continuum, I analyzed as to who (the learner or the teacher) took the responsibility for using an NRC feature. I specifically examined what scientifically-oriented questions were asked, who asked them,
what data or evidence were collected and interpreted, who developed procedures, who
developed explanations from evidence, who connected explanations to scientific
knowledge, who communicated and justified explanations, and what adaptations for
diverse learners needs were addressed. The last question, though not a feature of the
NRC (2000), was included in the analysis to investigate the extent to which the
preservice special education teachers as science instructors brought their special
education insights to their inquiry instruction. The analysis of the first two participants’
enactments of inquiry instruction is described in Table 3.

Next, to categorize participants’ enactments of inquiry instruction according to
the degree of learner-centeredness, I used the classification provided by Bell et al. (2005)
as described in Table 4.

This rubric enabled me to clearly identify who took responsibilities for the three
main constructs of scientific inquiry—asking questions, collecting data and finding
results during inquiry-based science teaching. With Brian and Paula’s inquiry
microteaching, since the teachers provided students with inquiry questions and the
procedures (refer to the video analysis as in Table 3), I coded their inquiry instruction as
a level 2 structured inquiry. Next, I open-coded the interview transcripts, lesson plans,
reflection papers and planning commentaries for codes related to their microteaching
experience. I constantly compared codes against each other and added new codes to the
list. Upon open coding all data sources, I compared open codes against five features
(NRC, 2000) using focused coding. Such a coding style allowed me to generate my final
code list, which included codes like teacher-directed inquiry instruction, discrepancy in
### Table 3

**Enactment of Inquiry Instruction by Brian and Paula**

<table>
<thead>
<tr>
<th>Components</th>
<th>Description/Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A drop in a Bucket! (3rd Grade Earth Science)</strong></td>
<td>Lesson aimed at learning about the different sources of water on earth and understanding their relative ratios. Students were given a globe to identify water sources. Then students were given a 5-gallon bucket of water that represented all the water on earth. Students were asked to estimate what amount from the bucket was drinkable. Students needed to measure out that amount from the bucket using the measuring cups, spoons and droppers.</td>
</tr>
</tbody>
</table>
| **What guiding questions asked?** (Italics if scientifically-oriented) | “Where do we find water?” T  
“Can we drink water from any of these sources?” T  
“Can we drink water that’s in the ocean?” T  
“Is all water on earth available for human use?” T  
“If the bucket represents all the water on earth’s surface, how much water do you think is drinkable?” T |
| **What data/evidence is collected/interpreted?** | S worked in small groups predicting amounts in percentages. Instructors wrote down predicted amounts on board. Students measured out their predicted amounts. T wrote down observed amounts on board to compare. |
| **Who developed procedure?** | T does not provide step by step procedures in the beginning. But when S struggled, T provided explicit instructions to each small group.  
“Now, let the bucket represent the ocean. I want you to scoop out what amount you think is drinkable. So go ahead—start taking water out.” (Brian, inquiry microteaching video, 7:20)  
“Here, now, if the bucket is all the water, which cup represents the lake?” (Paula, inquiry microteaching video, 8.20) |
| **Who develop explanations from evidence?** | T allowed students to compare predicted and observed amounts, but did all the explanations. Instructors explained that although there may be plenty of water on earth, only a small percentage was ready for human use.  
“Alright, let’s see the actual amounts. Let’s begin with oceans. So what percentage did you for oceans? 70? 90? 81? Well you are right. Ocean makes 97% of earths’ water.” (Brian, inquiry microteaching video 20:00)  
“I want you to understand that only 0.0003 % of water is available for human consumption.” (Brian, inquiry microteaching video 20:20) |

*table continues*
Table 3 (continued)

*Enactment of Inquiry Instruction by Brian and Paula*

<table>
<thead>
<tr>
<th>Components</th>
<th>Description/Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who connected explanations to scientific knowledge</td>
<td>T reviewed the sources of water on the earth, and reminded students how little water is available for human use, connecting to significance of water conservation.</td>
</tr>
<tr>
<td></td>
<td>“So you see—not all the water is drinkable. So we must use it carefully. We must not waste it.” (Paula, inquiry microteaching video 20:00)</td>
</tr>
<tr>
<td></td>
<td>“I want you to think about some ways we can conserve water. What can you do?” (Brian, inquiry microteaching video 21:00)</td>
</tr>
<tr>
<td>Who communicated and justified</td>
<td>Instructors reminded students that even if 75% of earth’s surface is water, only 0.0003 % of it is useable.</td>
</tr>
<tr>
<td></td>
<td>Brian— “So you see, less than 1% of earth’s water is drinkable.”</td>
</tr>
<tr>
<td></td>
<td>S—“Wow! I thought we could drink any water!”</td>
</tr>
<tr>
<td></td>
<td>(Brian, inquiry microteaching video 22:00)</td>
</tr>
<tr>
<td>Addressing modifications for diverse learners</td>
<td>Included in lesson plan only. Not addressed during teaching.</td>
</tr>
<tr>
<td>Key: T represents teacher, S represents students</td>
<td></td>
</tr>
</tbody>
</table>
Table 4

Rubric to Determine the Level of Inquiry Instruction (adapted from Bell et al., 2005)

<table>
<thead>
<tr>
<th>Level</th>
<th>Type</th>
<th>Who asks questions?</th>
<th>Who provides methods?</th>
<th>Who provides solutions/answers?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Confirmation Lab</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>2</td>
<td>Structured Inquiry</td>
<td>T</td>
<td>T</td>
<td>S</td>
</tr>
<tr>
<td>3</td>
<td>Guided Inquiry</td>
<td>T</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>4</td>
<td>Open Inquiry</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
</tbody>
</table>

Key: T indicates teachers, S indicates students

understanding inquiry instruction, discrepancy in understanding the levels of inquiry and addressing adaptation of inquiry. A full list of the final codes on participant’s enactment of inquiry can be found in Appendix D with exemplars from data.

Data analysis for Research Question 3. The third research question examined preservice special educations teachers’ views on teaching using inquiry. I collected data from interview transcripts, lesson plans, reflection papers, questionnaires, and planning commentaries. I analyzed the participants’ views on inquiry using the same analytical technique as in the previous questions. Data analysis began with open coding of the transcripts and other supporting documents, comparing data against each other and adding to the code list. I next compared codes against the five features (NRC, 2000) of inquiry. I paid close attention to the context in which these views appeared (classrooms with all learners, with general science students, or learners with disabilities) and color-coded them according to the context in which they appeared. I found applicability of
inquiry, benefits of inquiry, challenges to inquiry in special education context and adapting inquiry to be important views. A full list of the final codes on participant’s views on inquiry can be found in Appendix D with exemplars from data.

Data analysis for Research Question 4. I analyzed my fourth and final research question exploring special education teacher candidates’ future plans of inquiry using the same approach. I began with open coding of the transcripts, inquiry lesson plans, planning commentaries, reflection papers, and questionnaires to identify the initial open codes. Next, I performed focused coding with the five features (NRC, 2000) as a frame of reference to search for matches and mismatches against the NRC’s theoretical insights. Next I performed axial coding to compare future plans codes with other three constructs (understandings, enactment, and views) and compared data against insights found in empirical literature (teacher’s attitude towards inquiry, future instructional setting, challenges foreseen). Here again, I paid close attention to the context in which these codes appeared (all learners or general science learners or learners with disabilities) and color-coded them according to the contexts. I also found participants willing to teach inquiry in diverse instructional setting. They viewed lack of science content knowledge to be a potential concern to their future practice. A full list of the final codes on participant’s future plans of inquiry can be found in Appendix D with exemplars from the data. The details of data collection and data analysis as conducted in this research are provided in Table 5.
### Table 5

**Overview of Data Collection and Data Analysis**

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Construct</th>
<th>Data Sources</th>
<th>When Collected</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How do preservice special education teachers define and characterize scientific inquiry in a science methods course for special education majors?</td>
<td>Definitions and characterization of inquiry</td>
<td>Prequestionnaires Inquiry, Microteaching, Video Inquiry, Microteaching, Lesson Plan Inquiry, Microteaching Planning, Commentary Inquiry, Microteaching Reflection, Postquestionnaires Interviews</td>
<td>Day 1 (wk 1) 13&lt;sup&gt;th&lt;/sup&gt; and 14&lt;sup&gt;th&lt;/sup&gt; wk</td>
<td>Open coding of interview transcripts and other written data sources, focused coding, comparison against theoretical codes (NRC, 2000).</td>
</tr>
<tr>
<td>2. How do the preservice special education teachers teach by inquiry in the context of a science methods class?</td>
<td>Participant’s teaching by inquiry (Inquiry enactment)</td>
<td>Inquiry, Microteaching, Video Inquiry, Microteaching Lesson Plan Inquiry, Microteaching Planning, Commentary Inquiry, Microteaching Reflection, Postquestionnaires Interviews</td>
<td>13&lt;sup&gt;th&lt;/sup&gt; and 14&lt;sup&gt;th&lt;/sup&gt; wk</td>
<td>Video analysis against (NRC, 2000), Level assignment (Bell et al., 2005). Open coding written documents and interview transcripts, focused coding theoretical coding against NRC (2000) and Bell et al. (2005).</td>
</tr>
</tbody>
</table>

*(table continues)*
### Overview of Data Collection and Data Analysis

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Construct</th>
<th>Data Sources</th>
<th>When Collected</th>
<th>Data Analysis</th>
<th>Ensuring Trustworthiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. What are these teachers’ views toward scientific inquiry?</td>
<td>Teachers’ attitude towards inquiry</td>
<td>Inquiry, Microteaching, Lesson Plan, Inquiry, Microteaching, Planning, Commentary, Inquiry, Microteaching, Reflection, Postquestionnaires, Interviews</td>
<td>13th and 14th wk</td>
<td>Open coding of interview transcripts and other written data sources, focused coding, comparing codes against theoretical codes (NRC, 2000) and Bell et al. (2005).</td>
<td>Triangulation, Peer debriefing, Informal member checking</td>
</tr>
<tr>
<td>4. To what extent do preservice special education teachers plan to incorporate inquiry instruction in their future science classrooms after this science methods course?</td>
<td>Future plans, reasons for such inclusion decision, vision of future practice</td>
<td>Inquiry, Microteaching, Reflection, Postquestionnaires, Interviews</td>
<td>14th and 15th wk</td>
<td>Open coding of interview transcripts and other written data sources, focused coding against theoretical codes (NRC, 2000).</td>
<td>Triangulation, Peer debriefing, Informal member checking</td>
</tr>
</tbody>
</table>

### Ensuring Trustworthiness

I adopted a number of strategies to ensure trustworthiness of this qualitative research. Some of these strategies include: (a) credibility, which entailed a prolonged engagement with participants, persistent observations, triangulation of data and informal member checking; (b) transferability, which includes a thick description of research; and
(c) peer debriefing. I met with the participants every week for 15 weeks, each time for about three hours. Apart from my regular teaching hours, I spent at least 30 minutes after class to address additional questions from participants and recorded my own researcher memos (Charmaz, 2006).

To ensure trustworthiness of this qualitative research, I incorporated open coding techniques for data analysis along with triangulation, informal member checking and peer-debriefing. While open-coding (Strauss & Corbin, 1990) is a data analysis technique and might not be considered what qualitative researchers conceptualize as approaches to ensure trustworthiness of qualitative research, for me, it served the purpose of ensuring authenticity and reducing researcher bias during data analysis. The open coding technique allowed me to start my analysis from substantial, in-vivo codes that represented the participants’ own words and actions without incorporating theoretical insights or researchers’ insights (Charmaz, 2006). This technique, being a grounded theory approach (Strauss & Corbin, 1990), enabled me to develop the results from what emerged from the data keeping my bias toward inquiry separate. Furthermore, I adopted strategies like “waving the red flag” and far-out comparison techniques (Strauss & Corbin, 1990) to interpret participants’ responses more accurately.

The “waving the red flag” strategy allows qualitative researchers to accurately interpret what about the data is being represented. Open coding often starts with reading few words and bracketing them as soon as the researcher gets a conceptual meaning, but such initial conceptual labeling, if not done carefully, can change overall results (Charmaz, 2006). Strauss and Corbin (1990) suggested taking note of participants’ use of
sensitive words like “never,” “always,” “could not possibly be” in qualitative data sources while generating conceptual labels for open codes. Using this insight, I took note of any adjectives (e.g., “good,” “awesome,” “really bad”) that appeared immediately before or after an open code and waved the red flag if needed. For example, while focusing on definition and characterization of inquiry, as soon as I found an adjective associated with code about participant’s understanding of inquiry, I waved the red flag (Strauss & Corbin, 1990), reviewed the code, and converted the code to view of the participant if that was a closer fit. This technique thus enabled me to interpret the meanings of data in a more accurate way during my data analysis.

I used “far-out” comparison techniques (Strauss & Corbin, 1990) to keep unrelated codes separate from the final development of results. In this research, the interviews, being semi-structured, often allowed participants to diverge into topics not related to the project. While this kept the flow of conversation during the interview, I did not stop such conversations abruptly even when I found unrelated topics appearing in participants’ responses. Instead, I marked these unrelated codes as far-out codes and kept them separate from the rest of the analysis. One example of a far-out code would be learning about safety in science. One participant during the interview articulated how she learned about safety issues associated with science teaching in this course. While I labeled the responses about safety in science as a far-out comparison and kept it separate from the rest of the analysis since the code did not relate to the purpose of this study.

To address the trustworthiness of this qualitative research I also collected data from multiple sources and used the triangulation method (Merriam, 2009). I cross-
examined data obtained from multiple sources before placing them in a category. For each research question, I collected data from multiple sources and open-coded them. I constantly compared data against one another and searched for similarities and differences before placing them in a category. While similarities in themes allowed me to place a code into a category with confidence, differences in themes prompted me to relook at the data to investigate the differences (Merriam, 2009). Any inconsistency in findings was either addressed through triangulation or was excluded from the data. I incorporated informal member-checking with participants asking them for further clarifications if I needed them. This was another way I aimed to incorporate participants’ own voices and actions into final formulation of results.

I also employed peer-debriefing with two of my colleagues, one from the same program and another from a different program. I met with the science education colleague from time to time to explain my thought processes behind the data analysis, reflect upon my methodology, and explain my ideas behind the coding procedures. Upon completing data collection, I gave my code notes and 10 blank transcripts to the peer debriefer and asked her to code them. Picking up one participant, we shared how each coded the same transcript independently and discussed coding differences. I found my science education peer debriefer’s coding matching with my own coding. My second peer-debriefer read my code notes and became informed of the five features (NRC, 2000) and then coded three blank transcripts. Here, also, most of his conceptual codes matched with my focused coding and any disagreements in coding were discussed until reaching a consensus (Merriam, 2009).
Finally, to ensure ethical compliance, I applied and obtained approval of the study from the university’s Institutional Review Board (IRB). This included securing an informed consent, written in a language understandable by the participants as well as other related information about the purpose, expected duration, procedures, risks and benefits associated with the project, and the participants’ rights to participate and withdraw from the project any time. Each prospective special education teacher agreeing to participate in this study received a signed copy of the consent form.
CHAPTER IV

RESULTS

This chapter describes the results of a qualitative research that explored preservice special education teachers’ understandings, enactments, views, and plans for inquiry. Understandings included examining how participants defined (i.e., described \textit{what inquiry is}) and characterized inquiry (i.e., described \textit{how inquiry is done}); enactments of inquiry instruction referred to how participants \textit{taught a science lesson using inquiry} during their microteaching. Participants’ understandings, enactments, views, and plans were qualitatively analyzed (Merriam, 2009; Strauss & Corbin, 1990) and compared to the NRC’s (2000) version of inquiry to identify matches and mismatches between participants’ interpretations and NRC (2000) \textit{while} they learned about inquiry in a K–8 general science methods class.

This chapter is organized as follows: It first revisits the four research questions that guided this qualitative research. The chapter next revisits the five essential features (NRC, 2000) that served as the theoretical framework of inquiry in this project. The results of research are then disseminated question by question, with key findings listed at the beginning of each research question and described in detail with supporting examples from various data sources. This chapter concludes with a synopsis of the major findings from all four research questions.

The four research questions explored in this qualitative research were:

1. How do preservice special education teachers define and characterize scientific inquiry in a general science methods class? How do preservice
special education teachers enact their inquiry instruction in the context of a science methods course?

2. What are these preservice special education teachers’ views on teaching using scientific inquiry?

3. To what extent do preservice special education teachers plan to incorporate inquiry instruction in their future science classrooms?
   a. What reasons do they offer to explain their inquiry inclusion decisions?
   b. For those who intend to incorporate inquiry instruction in their future teaching, how do they envision utilizing this method?

The five practices that the NRC (NRC, 2000) endorsed as the five essential features of inquiry are: (a) Learners are engaged by scientifically oriented questions; (b) Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions; (c) Learners formulate explanations from evidence to address scientifically oriented questions; (d) Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding; and (e) Learners communicate and justify their proposed explanations (NRC, 2000). I employed these features as a frame of reference to interpret participants’ understandings, enactments, views, and plans for inquiry. I collected qualitative data from multiple sources representing participants’ own voices and actions (Merriam, 2009) and analyzed them using grounded theory (Strauss & Corbin, 1990). The results of such analysis are described below question by question.
Findings to Research Question 1: Defining and Characterizing Inquiry

The first research question investigated how preservice special education teachers defined (described *what inquiry is*) and characterized (described *how inquiry is done*) inquiry. Data gathered from interviews, pre- and post-questionnaires, inquiry microteaching videos, inquiry microteaching lesson plans, inquiry microteaching planning commentaries and inquiry microteaching reflection papers. Data analysis transpired using a grounded theory approach (Strauss & Corbin, 1990) and comparison against the NRC’s (2000) framework of inquiry. Participants’ definitions and characterizations held both matches and mismatches with insights provided by the NRC (2000). See Figure 1.

Defining and Characterizing Inquiry From the Learner’s Perspective

Seven of the study participants defined inquiry as a *learning method*, describing inquiry from the learner’s perspective. They characterized inquiry in terms of what students *do* in an inquiry environment and how *students* use the five essential of inquiry. While defining inquiry can be a match with theoretical insights provided by the NRC (2000) since all five features are written from the *learner’s perspective*, several misinterpretations of the features were also identified. The following cases illustrate such matches and mismatches between participants’ understandings and the NRC’s (2000) version of inquiry.
Theoretical codes and emergent codes for Research Question 1: Preservice special education teachers’ definitions and characterizations of scientific inquiry (with theoretical codes italicized).

The first example is Jack, a graduate level Special Education major with a Mild to Moderate Educational Needs emphasis who defined scientific inquiry as “Getting students to come up with their own ideas, checking hypothesis of how stuff happens.”

Jack considered inquiry as learning where students have to interpret evidence. He added, “You have to come up with evidence to back up your hypothesis—your idea. If there is no evidence to back it up, then it is just like—as if you tell a story.” Clearly, Jack’s
definition matched two constructs found in the NRC (2000)—one, that inquiry involves students taking part in their own learning, and two, that such learning occurs by giving priority to evidence.

When I asked Jack how he would characterize scientific inquiry, he responded, “With the five E’s.” While Jack did not specifically indicate in the interview what these five E’s were, data from other sources led me to believe that he was indicating the five essential features of inquiry. For example, in his inquiry microteaching reflection paper Jack wrote:

We provided them materials, but the students planned and conducted their own investigations of how they got the ball to move and stop as well as discovered scientific ideas on their own. The students collected their own data and analyzed and drew their own conclusions. Mike and I did not tell the students how to get the ball to move or stop; we simply asked how they themselves could do it which allowed them to come up with their own ideas and conclusions. (Jack, Inquiry Microteaching Reflection Paper)

Here, Jack’s understanding that inquiry learning involved students learning by interpreting evidence became clear. Jack considered students collecting and analyzing data and coming to a conclusion to be an important feature of inquiry learning since it involved students’ own meaning-making of evidence, an idea similar to the NRC’s (2000) conceptualization of inquiry.

Further, during the interview, Jack indicated that “[Inquiry] would be where we get to explain somebody not all but how most of things happen.” Here, Jack not only
identified that learning by scientific inquiry facilitated the development of scientific knowledge, but he also demonstrated his own understanding of how scientific knowledge develops. Jack informed me that learning via inquiry allowed students to understand not all, but most of how the world functions—clearly demonstrating his understanding that scientific knowledge is tentative and based on evidence. Still, this was the only data source from Jack where he expressed such an informed understanding of the purpose of learning using inquiry.

My second example is Francine, an undergraduate Special Education major with a Mild to Moderate Educational Needs emphasis. Francine likewise demonstrated an understanding of two constructs fundamental to inquiry learning: one, that scientific inquiry involved first-hand experience by students, and two, that inquiry involved interpreting evidence. “I would tell them that it is more of like questions and discovery-based,” Francine indicated as she defined inquiry. She characterized scientific inquiry as students asking questions and exploring answers by themselves. She elaborated, “It’s just more like asking questions and having them figure out what happens or what they need to learn as opposed to being told like ‘you need to know why this happens’—as in lecture.” She further used an example to describe her thoughts: “Inquiry would be like ‘so what do you think it would be if water gets really cold?’ So, it is more like discovering by them as opposed to you forcing it on them.” She considered students learning by seeing and understanding rather than being told, which matches with the NRC (2000). But her understanding also demonstrated some differences with NRC’s conceptualization. Francine compared inquiry to lecture, and this is a method of teaching science. “Inquiry
is more of like questions and discovery based as opposed to lecturing about,” she indicated during the interview. This expressed an overlap in her understanding of inquiry learning and teaching using inquiry instruction.

In Francine’s inquiry microteaching planning commentary, a similar theme of evidence-based learning appeared. Francine’s group indicated, “We chose to do this activity because [with] the hands-on experience, the students can see and relate to this as they connect it to common household items and events” (Francine’s group, Inquiry Microteaching Planning Commentary; emphasis added). Here, Francine might have considered inquiry-based learning to provide opportunities for learners to understand science concepts by direct experiences such as observing and connecting observations to concepts. In her teaching video, however, teachers provided various real-life examples rather than generated by the learners. This indicated that Francine also considered teachers to use features such as Connecting to Scientific Knowledge to support learning in students. For example, Francine’s group provided several real-life examples of physical and chemical changes before their activity using PowerPoint slides and told her students how each example was a physical or a chemical change. She noted, “Crushing a can, melting ice cubes those are all examples of physical changes. They can be brought back. Examples of chemical changes are rusting of a car or baking a cake” (Francine, Microteaching Video).

Francine also demonstrated a mismatch between understanding the Explaining and Communicating and Justifying features of inquiry. During the interview, she came to describe how her group had to support meaning-making in their students during their
own inquiry instruction. She explained, “We had to kind of explain why that happened—like we saw that the balloon blew up and it was like a physical kind of change because blew up, but the inside—there was a chemical change that produced the gas that helped the balloon to blow up” (Francine, interview). While explaining to the students that the balloon blowing up was an observable physical change as justifying results of the activity, Francine considered this as Explaining results rather than Communicating and Justifying results in terms of evidence. While interpreting her own inquiry instruction using five features, she voiced her confusion. She said, “As for the communicating and justifying part, I really still don’t quite understand what that part is—like what is the difference between explaining the findings and justifying it?” (Francine, interview). Her difficulties possibly arose from an overlap between understanding Explaining and Communicating and Justifying features of inquiry. Here, she used the features as teachers of science rather than letting her students use them as described by the NRC (2000), but in doing so, struggled to understand the purposes of such features as described by the NRC. Nevertheless, her understanding of inquiry to be similar (even if only partially similar) to image inquiry as conceptualized by the NRC since she understood that inquiry involved students taking part in their own learning via direct experience. Yet this was not a fully informed understanding since she was also confused about the Justifying and Communicating part of inquiry.

A third participant who defined inquiry from the learner’s perspective was Holly, a graduate level Special Education major with a Mild to Moderate Educational Needs emphasis. Holly defined scientific inquiry in the following way:
It’s all about your personal exploration in science and finding your own answer.

Sometimes I think with some students they need more of a structure and you have to provide that. And I think that’s what’s key. And also key is really to get people to look at their world scientifically and hope that it’s going to make them a better citizen, a better consumer. (Holly, interview)

From these statements, three notions can be asserted. First, Holly understood that inquiry allowed students to take part in their own learning; second, she felt that teachers needed to guide students during inquiry-based learning and three, scientific inquiry prompted students to understand how the world functioned around them. All three can be considered matches with the NRC (2000), though she brought in the element of teacher-guidance in the process, which is not explicitly stated in the five features of inquiry (NRC, 2000), although variations of inquiry indicate variable teacher-guidance.

Holly characterized inquiry in terms of the “five E’s,” but when asked to elaborate the “five E’s,” she responded:

It’s asking and that’s how you need to take the class and hook them in. And then you don’t tell them how to solve a problem, but you can give them some kind of support. And then it’s really to be crucial. I’m explaining the Five E’s because I thought it’d be easier. And then, you get together and after you do all of this you get together and you explain—why you chose to do the things you did. And then—also when the teacher was walking around you could also do an assessment so you have that component too. And then the extension is huge. It’s
like—you know life examples and things that people can relate to. (Holly, interview)

With this statement, Holly’s characterization of inquiry indicated an overlap in understanding inquiry learning versus teaching students using inquiry using the five-E Learning Cycle (Bybee, 2000). The Learning Cycle instructional model (Bybee, 2000) is a tool for science teachers to plan for inquiry instruction, not a direct reflection on how students learn in an inquiry environment. But according to Holly, the Learning Cycle model characterized inquiry, thereby demonstrating an overlap in conceptualizing inquiry learning versus inquiry teaching.

Holly also strongly felt that teacher guidance was fundamental during inquiry learning, something not explicitly stated in the five features of classroom inquiry (NRC, 2000), but found in its variations. Her group’s inquiry microteaching lesson plan also indicated a similar overlap where her inquiry instructional sequence was juxtaposed with the five essential features (NRC, 2000). Since Holly told me that she explained inquiry in terms of five E’s because “it was easier to describe that way,” it can be assumed that she thought that the five E’s easily describe inquiry instruction rather than scientific inquiry. Holly probably conceptualized inquiry as students learning with the NRC’s features but doing so with the teacher’s guidance.

A fourth participant who also defined inquiry from the learners’ perspective was Gail, an undergraduate Special Education major with a Mild to Moderate Educational Needs emphasis. Gail defined inquiry as “Learning through doing.” Gail characterized inquiry by describing how students ask questions and answer them by looking at
evidence. Gail considered that interpreting evidence was an important aspect that characterized scientific inquiry because “[students] are taking the questions that they have and having to know what they are looking for. Having to be able to justify that later—having to go forward and justifying something” (Gail, interview). This indicates that Gail considered that gathering and interpreting evidence prompted students to start searching for answers to their inquiry questions and justifying results in terms of evidence, both constructs found in the NRC (2000). In her post-course questionnaire, Gail indicated “emphasis on students’ explorations and inquiry” (Gail, post-questionnaire) as two major ideas that she learned from this inquiry-based science methods class. Clearly, Gail conceptualized inquiry from the learners’ perspective, indicating how students learn by asking questions and exploring the answers for themselves, an idea similar to the NRC.

On the contrary, in the interview, Gail also described inquiry as “an approach to teach science, which is not entirely teacher-directed” (Gail, interview). Her response demonstrated both matches and mismatches with the NRC (2000). While she identified student-centered nature of inquiry learning, which matched the NRC, she described inquiry learning in terms of inquiry instruction, indicating an overlap between understanding inquiry learning and teaching using inquiry. Thus, Gail also exhibited an understanding that only to some extent correlated with the NRC’s image of inquiry.

The fifth participant who described inquiry from the learner’s perspective was Ida, another graduate level student of Special Education with a Mild to Moderate Educational Needs emphasis. Ida defined scientific inquiry in the following way: “It’s
about how people are finding out about the information through their observations and studies and what questions they ask from their research” (Ida, interview). She quickly added, “It’s not so much about finding the answer or anything but the process behind it—and the thinking and the understanding of it.” The remarks show that Ida understood inquiry as how students learn via doing and reflecting on their experiences, which is a fundamental theoretical construct of inquiry (NRC, 2000). But unlike earlier participants, her response did not explicitly address the use of specific features of inquiry or how they related to the building of scientific knowledge by giving priority to evidence. In addition, her understanding also demonstrated an overlap between inquiry learning and teaching using inquiry, since she also indicated how she and her partner, as teachers of science, used several questions to guide students’ learning during their own microteaching and still considered the teacher-questions as a part of inquiry. To elaborate how her group demonstrated inquiry instruction, she reflected:

Because we walked around while the students were working and we asked them a lot of questions. One of the questions was—how do you know? Or if birds use mud in their nests what do they do if there’s a drought and it’s not muddy enough? Mud is dry. What do you think they are going to do? So we would try to ask questions and get them thinking. (Ida, interview)

Ida not only gave questions to her students, rather than allowing her students to develop their own inquiry questions, but also did so to guide students’ thinking rather than prompting them to collect evidence. This can be considered a mismatch against NRC (2000) descriptions of inquiry where learners ask scientifically-oriented questions to
collect and analyze data as evidence. Despite holding an informed view of how inquiry learning leads to understanding, Ida’s conceptualization demonstrated a partial understanding of inquiry.

The sixth participant who defined inquiry from the learner’s perspective was Debra, a Special Education major with a Mild to Moderate Educational Needs emphasis. Debra defined inquiry as “where you give your students a chance to discover scientific things—like discoveries and observation on their own.” While Debra acknowledged that inquiry involved students learning via observing and interpreting evidence, she also believed that teachers create a path for such learning in their students. While the first part of her definition indicated a match with the NRC (2000), the second part indicated an overlap in her understanding of inquiry learning and teaching using inquiry. Her inquiry microteaching reflection paper also displayed similar matches and mismatches: “We let students discover their own scientific ideas. They knew what we wanted them to observe, but they were free to discover anything they could” (Debra, Inquiry Reflection Paper). Consistent with previous findings, the matches and mismatches with the NRC became apparent. While Debra felt that she allowed students to discover scientific concepts on their own using inquiry—which can be considered a match with the NRC, she also felt that the students knew what was going to happen and followed teachers’ instruction toward the expected outcome. Debra’s response included the idea that students are expected to know the desired result before gathering and interpreting data, which is inconsistent with the NRC’s “formulating explanations from evidence.” Debra characterized inquiry in terms of the “five E’s,” but when I asked her what these five E’s
were, she expressed that she was confused with the two constructs. To explain her five E’s, she hesitated for a moment: “It’s like—um—explore—um—elaborate,” but then added, “I am sorry I am getting confused right now with the Learning Cycle.” Nonetheless, the instructional sequence in her inquiry microteaching lesson plan was written in terms of the five E’s of the Learning Cycle as required by the assignment, and her inquiry microteaching video did demonstrate an understanding of all five essential features of inquiry. Perhaps she understood each construct separately but could not relate them to one another. However, she emerged as the only participant who recognized her own confusion with the two theoretical constructs.

The seventh participant who characterized inquiry from the learner’s perspective was Brian, a Special Education major with a Mild to Moderate Educational Needs with a Language Arts and Reading (LAR) emphasis whose understanding demonstrated both matches and mismatches with the NRC (2000). During the interview, Brian defined inquiry in the following way: “I would say that it is a learning method that was based on questioning.” He further added, “Questions, leading to answers, leading to more questions” (Brian, interview). Here, Brian considered inquiry to incorporate learning in students by asking questions and finding answers to the questions, which was similar to the NRC. In his group’s inquiry microteaching planning commentary, he explained, “We chose this [inquiry] activity that would help children to have a greater understanding by seeing” (Brian, Inquiry Planning Commentary; emphasis added), thereby considering learning via interpreting observations as a part of inquiry learning for students. But Brian characterized inquiry in terms of the “five E’s,” this time indicating an overlap between
inquiry learning and teaching using inquiry. While Brian did not elaborate on what these five features were, he did indicate that the five features allowed teachers to plan for inquiry. This showed an overlap with inquiry learning and inquiry instruction in Brian’s thinking.

Moreover, Brian considered that questioning was a key feature of inquiry but indicated how teachers use questions to scaffold learning. He characterized inquiry as “asking questions, giving questions, and recalling their prior knowledge through these questions, it kind of gives a clear cut way to get your students into your vein of thought.” This response indicates two mismatches against the NRC’s (2000) insights. Brian indicated that questions are asked by teachers during inquiry learning, which can be the first mismatch with NRC where learners develop their own questions. Also, Brian indicated that questioning assessed prior knowledge and guided students’ thinking. This was also a mismatch, since questioning, according to the NRC, needed to be scientifically-oriented, guiding students toward data collection and analysis (NRC, 2000). Thus, while some of Brian’s understandings matched the NRC’s conceptualization, some of his understandings differed.

It thus became clear that all these above participants defined inquiry from the learners’ perspective. Still, many of their interpretations indicated an overlap in understanding inquiry learning and teaching using inquiry, since many of the participants’ conceptualizations involved how teachers use certain features of inquiry to guide learning in students. Despite including the idea of teacher-guidance in the process,
all the participants conceptualized inquiry from the learner’s perspective, identifying that inquiry involved students taking part in their own learning.

**Defining and Characterizing Inquiry From the Teacher’s Perspective**

While the above participants defined inquiry from the learner’s perspective, the following nine participants considered inquiry to be a *teaching* method, clearly juxtaposing inquiry learning with inquiry teaching. This image mismatches with the NRC (2000) because all of the five features are written from the learner’s perspective. Additionally, a second level of mismatch against the NRC’s features became evident when participants not only indicated that *teachers* used the features of inquiry but used the features with *purposes* that *differed* from those described by the NRC. The following key examples are presented from the data, organized according to the closest to farthest match with the NRC’s image of inquiry.

Kim, an undergraduate Special Education major with a Moderate to Intense Educational Needs emphasis, defined scientific inquiry in the following way: “[Inquiry] is asking questions to the students so that they can lead to their own experiences and manipulate things and come up with their own questions.” Here, it became evident that Kim thought that questions are asked by the teachers, which then lead students to commence their own explorations. While this holds true for inquiry instruction where teachers may provide questions to their learners during inquiry investigation, this also differed from learners asking scientifically-oriented questions (NRC, 2000). Kim characterized inquiry learning as “asking questions, [looking at] evidence, explaining what you find, leading to group discussions and justifying what you find.” She did not
mention explicitly who used these features—teachers or students. In her interview, however, she compared inquiry to lectures while describing how inquiry supported learning in students. She explained, “Any time [teachers] do hands-on activity rather than a lecture, I think it is easier to connect to” (Kim, interview).

Such a comparison revealed an overlap in understanding inquiry-based learning and teaching using inquiry instruction. In her reflection paper, Kim interpreted her own inquiry instruction: “We prompted students to discover the experimental process on their own. There was some support from us as teachers, but we wanted the students to decide on the steps for the experiments themselves” (Inquiry Microteaching Reflection, Kim). In this instance, Kim considered teachers providing support to learners’ own discoveries as a part of inquiry instruction. Furthermore, Kim interpreted the purpose of questions during inquiry-based learning quite differently from the NRC’s (2000) description. In her reflection paper Kim wrote, “Our teaching was better this time. We had a lot more questions this time that promoted the students to think deeper about the subject and what they would be learning for the lesson” (Inquiry Microteaching Reflection, Kim). In this statement, at least two mismatches with the NRC image of inquiry-based learning existed. First, Kim suggested that questions needed to be asked by teachers and not students as in the NRC. Second, Kim considered questions to promote critical thinking in students, which is different from prompting the collection and interpretation of data as evidence as in the NRC. Despite such mismatches, Kim acknowledged that students take part in their own learning during inquiry: “They get to experience it hands on and get to
see it firsthand instead of just listening about it sitting there” (Kim, interview); this concept, could also be found in the NRC’s version of inquiry.

Luke, an undergraduate level Special Education major with a Moderate to Intense Educational Needs emphasis, displayed similar thinking as Kim. Luke defined inquiry as “a way of teaching through questioning and guiding students at different levels” (Luke, interview). In this statement, Luke not only considered inquiry learning in terms of inquiry instruction, but also expressed how teachers use the features differently than the NRC (2000). Luke described inquiry in the following way:

You want students to ask questions first and then you want them to explore and look for evidence. And usually an activity I think. And then after that, you’re going to go more into the content and explain what you just saw or did during your activity and then kind of clear everything up. (Luke, interview)

Luke thus demonstrated an overlap between inquiry learning and inquiry teaching. While he considered inquiry to involve students asking questions and looking for evidence, he also considered teachers as providing such opportunities for students as reflected by the phrase “you want to” in the above excerpt. After identifying that students ask questions and look for evidence, Luke identified how teachers provide guidance to students. Luke believed teachers rather than learners use the features of inquiry (NRC, 2000). For example, Luke described how teachers debrief results of investigations and communicate and justify results in terms of evidence. It should also be noted that Luke used the term explain to describe how teachers debrief an activity by justifying it in terms of evidence, showing an overlap in understanding the Explain and Communicate and Justify features
of inquiry (NRC, 2000). As a result, despite considering inquiry learning to be a teacher-guided process, Luke did recognize students asking questions and looking at evidence, thus demonstrating at least a partial understanding of the NRC. Interestingly, Luke also placed importance on learning about *science content* using this method, a trend not found in other participants’ definitions of inquiry.

Another participant who defined inquiry as a teaching method in the interview was Olivia, a graduate level Special Education major with Early Childhood Intervention emphasis. Olivia defined inquiry as: “A teaching method where you would use a lot of questioning, but you try to get the students to come up with the answers.” In this statement, Olivia, like Kim, suggested that teachers asking questions to lead students’ explorations to be a part of inquiry learning. Olivia characterized inquiry in the following way:

You are going to start by using something to grab their attention. You are going to plant a seed with a question. “What would happen if”—you know—whatever the content is that you are teaching. So it’s going to be engaging. Then you are going to let them explore through whatever investigation it is. Then after you are getting it done, you are probably going to explain the content. Then you would try to extend their knowledge—see if they can apply this knowledge elsewhere, and finally you are going to communicate and justify—kind of debrief as to what the learning are. (Olivia, interview)

Olivia juxtaposed inquiry learning with inquiry instruction since her description indicated a blend of both theoretical constructs—the five E’s of the Learning Cycle model (Bybee,
2000) and the five essential features of inquiry (NRC, 2000). For instance, even when she considered questions to begin inquiry investigations, which is indeed a feature of the NRC, she referred to questions as coming from teachers—questions that are engaging, thus referring back to the first E of the Learning Cycle, which is Engage. Again, following explanation of content, she proceeded to Extending (a Learning Cycle component, and not an inquiry feature of the NRC) but immediately following the extension component, she returned to Communicate and Justify, which again is a feature of inquiry (NRC, 2000). Olivia clearly exhibited an overlap in understanding essential features of inquiry and the Learning Cycle elements. In confusing the two, Olivia conceptualized inquiry in terms of inquiry instruction, since the Learning Cycle describes how teachers may plan for inquiry instruction (Bybee, 2000). She thus held an understanding of inquiry that only partially matched with the NRC (2000).

Olivia’s inquiry reflection paper mirrored the same overlap in understanding inquiry learning and inquiry instruction. Olivia wrote:

We (the teachers) posed the questions to the students . . . and the students conducted the investigations. The students were the ones who discovered the scientific ideas related to the experiment (properties of density). The teachers did the content and the debriefing, which further explained our scientific ideas on density. (Olivia, Inquiry Microteaching Reflection)

Olivia described inquiry learning and inquiry instruction. She assumed that teachers posed questions to initiate students’ investigations. She indicated that following student explorations, the teachers debriefed the activity to the students. Similar to Luke and
Francine, Olivia used the term *Explain* to describe how teachers debrief an activity by justifying it in terms of evidence, indicating an overlap in understanding the *Explain* and *Communicate and Justify* features of inquiry (NRC, 2000). In doing this, Olivia illustrated inquiry in terms of inquiry instruction. All these themes led me to assert that Olivia, like other participants, held an incomplete understanding of the five features of inquiry as described by the NRC (2000).

Carol, an undergraduate Special Education major with a Mild to Moderate Educational Needs emphasis, held similar viewpoints as the above participants and perceived inquiry as a teaching method. Carol defined inquiry as: “Teaching a lesson by asking questions.” She further added, “It is kind of student-driven, and kind of giving a lot of the responsibilities to the students and not telling them what to do.” A similar theme appeared in Carol’s inquiry microteaching reflection paper, where she wrote, “We, as teachers, posed questions for our students but we let them plan and conduct investigations as well as discover scientific ideas” (Carol, Inquiry Microteaching Reflection). Here, she conveyed that students learn scientific concepts by conducting inquiry investigations. She also believed that teachers posed the questions to initiate such investigations. Later in the interview, when I asked her how she would characterize inquiry, she responded, “Teachers asking questions and explaining findings.” Carol considered *teachers* to be the source of questions and felt they should debrief students’ activities to characterize teaching using inquiry. Like the above participants, Carol also employed the term *Explain* to describe how teachers debrief an activity by justifying it in
terms of evidence, indicating an overlap in understanding the *Explain* and *Communicate and Justify* features of inquiry (NRC, 2000).

An interesting case was found with Paula, a graduate Special Education major with an Early Childhood Intervention emphasis, who put forward a unique perspective about the role of evidence in inquiry. When asked to define scientific inquiry, Paula responded, “[Inquiry] would be like asking questions, looking into exploring the answers.” While she did not explain her thoughts further in the interview, she still valued students taking part in searching for the answers. In an example, as she reflected on her own inquiry microteaching, Paula indicated that her group did involve her peers (posed as her students) in the search for data as evidence:

Looking for evidence was it was like having them take what they have in front of them, written on paper and what we had on board and then searching through it. Kind of thinking through with what they had and using that to find out something. And kind of visually seeing them, this as a definite evidence to what they are searching. (Paula, interview)

Paula not only considered examining evidence to be a part of inquiry learning, but also interpreted examining evidence as a way to reinforce learning in students. In the above excerpt, she referred to students being given *multiple opportunities* to interact with evidence to understand inquiry during an inquiry-based learning. While the students’ involvement may match NRC (2000) conceptualizations of inquiry, their examination of evidence to reinforce learning differs somewhat from the NRC’s. Nevertheless, the role
of looking at evidence with guidance from teachers is evident in other data collected from Paula.

In her inquiry reflection paper, Paula wrote: “When I noticed one group asking me a question about locating the water sources, rather than giving them the answer, I brought over the globe and guided them in their discovery” (Paula, Inquiry Microteaching Reflection). Once again, Paula considered guiding students toward their own learning via examining data by themselves to be a key construct of inquiry learning. Still, Paula came to be the only participant who indicated that young children may not be able to interpret evidence. During her interview she indicated, “Looking for evidence—I don’t know if we do it much in the preschool class. I think that’s a feature that’s little too hard for them.” Furthermore, toward her own inquiry microteaching, she felt that she was out of her comfort zone and played a limited role in interpreting data as evidence during her group’s inquiry teaching (her partner teacher, Brian, did all the data analysis for their students). From all these results, I inferred that Paula struggled to understand the role of evidence in inquiry and as a result believed that her students also might not be able to learn by interpreting evidence. Her understanding of inquiry thus exhibited only a partial match since she struggled with the Looking at Evidence feature of inquiry (NRC, 2000).

Another student, Mike, an undergraduate Special Education major with a Moderate to Intense Needs emphasis, also defined inquiry as a teaching method, but this time he showed another interpretation of inquiry. Mike defined inquiry in the following way during the interview: “I would say—it is teaching in a manner that provokes thought.
I guess it provokes students to explore further and develop their own understanding as opposed to a book definition of the topic you’re trying to teach.” This shows that Mike understands that inquiry involves students taking part in their own learning and encourages critical thinking in students. However, he also defined inquiry from the science teacher’s perspective and considered inquiry to be different from the textbook-based teaching of science, where he juxtaposed inquiry learning with inquiry teaching.

Until this point, Mike had exhibited an understanding (overlap inquiry learning with inquiry teaching) that I found in many earlier participants. But when asked to characterize scientific inquiry, Mike interpreted inquiry in a completely new way, not found in any earlier participants. When I asked Mike to identify some features of inquiry, Mike only responded, “asking the right questions.” Mike was referring to the Elstgeest (2001) article on productive questioning, which involved teachers using questioning to guide science learning in children. But Mike considered productive questioning to be synonymous to inquiry instruction. Both matches and mismatches in understanding led me to conclude that Mike interpreted inquiry in a way that matched only partially with that of the NRC (2000).

Interpreting inquiry as a guiding technique using teacher questioning became apparent even more strongly in another participant: Nancy, an undergraduate Moderate to Intense Educational Needs major. Nancy defined and characterized inquiry as “asking the right question at the right time” (Nancy, interview). Here, as with Mike, Nancy considered teachers using questioning to scaffold learning to be a part of teaching using inquiry. Her interpretation did not include students in any way, unlike Mike, who
recognized that inquiry learning involved students exploring and developing their own understanding to some extent. Because of this, Nancy’s interpretation of learning by inquiry differed completely from the NRC’s (2000).

Another unique interpretation of inquiry came from Adam, an undergraduate Special Education major with Mild to Moderate Educational Needs with a LAR emphasis, who also defined inquiry as “the Five E’s.” When asked what these five E’s were, he stated, “Exploring, Engage, Explain and Collaborating.” He further elaborated:

I think relating to their prior knowledge is important because I know you go in a class a lot of times saying “I’m dumb” and the teacher will start something but then you’re not sure, so you’re automatically behind right from the beginning. So I think like checking the prior knowledge to where all the kids are and then you just start with them from there. You kind of combine what you get from there.

(Adam, interview)

He further explained the role of questions was to “keep everybody on the same page” (Adam, interview). With this, Adam incorporated a number of themes in his interpretation of inquiry, some of which cannot be found in the NRC (2000). First, Adam considered activating prior knowledge to be an essential part of inquiry, a purpose not directly embodied in the NRC’s features. Second, Adam believed questions assessed student learning during inquiry, which is different from students developing scientifically-oriented questioning. However, Adam considered children asking questions during inquiry to be a part of inquiry, a view that aligned with the NRC. Adam’s understanding of inquiry indicated a blend of perspectives taught in the class
with an incorporation of his own thinking, thereby developing an image that partially matched with the NRC model of inquiry.

Yet another unique interpretation of inquiry came from Emily, who also majored in Mild to Moderate Educational Needs. Emily considered inquiry to be a scaffolding technique that provides in-depth instruction in students. Emily defined inquiry in the following way:

[Inquiry is] like you want to take something and extend it. You want to pull it out to really good detail with it and inquiry just does that automatically. Instead of maybe the top level, inquiry allows that time to get deep into it. (Emily, interview)

Emily’s response exhibited multiple mismatches with NRC’s definition of inquiry. First, she conceptualized scientific inquiry from the teachers’ perspective instead of the learners’ perspective as described by the NRC (2000). This indicated an overlap between understanding inquiry learning and inquiry instruction. Further, she considered inquiry instruction to be a scaffolding technique that ensured greater depth of instruction, an understanding not found in the NRC’s version of inquiry. Thus, Emily held an understanding of inquiry learning that differed from descriptions provided by the NRC.

**Inquiry in Terms of What it is Not**

A number of participants proceeded to define and characterize inquiry in terms of what inquiry was *not*, once again illustrating matches and mismatches against the NRC’s (2000) theoretical constructs. The participants conceptualized inquiry as a learning method, teaching method, or scaffolding technique. Some participants described inquiry
in terms of what students did not do in an inquiry-learning environment. For example, inquiry was “not memorizing, but understanding” (Olivia, interview), “not just reading” (Paula, interview), “doing something besides just staring at the teacher” (Francine, interview). These participants all conceptualized inquiry from the learners’ perspective, which is a match with the NRC’s since the features also describe the active roles for students (NRC, 2000).

Conversely, some of the participants described inquiry in terms of what teachers did not do in an inquiry environment. For example, inquiry consisted of “guiding students instead of talking at them” (Emily, interview), being “opposed to lecturing” (Francine, interview), “not entirely teacher-directed” (Gail, interview), “not teaching strictly content” (Luke, interview), “opposed to teaching a book definition” (Mike, interview). All these participants understood how inquiry instruction differed from other forms of science instruction. While describing inquiry in terms of inquiry instruction, they exhibited, however, an overlap between inquiry learning and teaching using inquiry. This was a mismatch with the NRC’s (2000) image of inquiry, which focuses on how students learn science by interpreting evidence.

Summary of Results for Research Question 1

The studied preservice special education teachers defined (described what inquiry is) and characterized (described how inquiry is done) inquiry in a variety of ways, some responses matching the theoretical insights provided by the NRC (2000), and others not. Participants seldom conceptualized inquiry from the learners’ perspective, as conceptualized by the NRC. The seven participants who conceptualized inquiry from the
learner’s perspective often indicated an overlap between inquiry learning and teaching using inquiry instruction. These participants showed how teachers, at times, use inquiry features with purposes extremely differently from what is described in the NRC. Participants not only interpreted inquiry in terms of inquiry instruction but also described the inquiry features rather differently from what is described by the NRC.

In terms of the five features, participants’ conceptualizations mostly included the first three features of inquiry (NRC, 2000)—asking questions, looking at evidence, and explaining results to students. More participants indicated that teachers asked questions to initiate inquiry investigations. Sometimes participants used questioning with purposes such as scaffolding instruction or directing students’ thoughts and *still* considered such questioning to be a part of inquiry. The participants seldom recognized inquiry as *allowing students to interpret evidence*, though many of them referred to students taking part in hands on experiences during inquiry learning. Participants as science instructors often considered teachers debriefing the activities to their students as part of inquiry learning. In many such instances, participants’ understanding overlapped between *Explaining* results of an inquiry activity and *Communicating and Justifying* results. All such results led me to conclude that participants in the study exhibited an understanding that only partially matched the theoretical insights provided by the NRC (2000).

**Findings to Research Question 2: Enacting Inquiry Instruction**

This question analyzed participants’ enactment of inquiry instruction in front of their peers during an inquiry-based microteaching assignment. While participants’ teaching videos appeared as the primary source of data for this question, I also examined
supporting documents such as participants’ inquiry lesson plans, inquiry planning commentaries, inquiry reflection papers, and interview transcripts. Notably, the participants remained free to obtain ideas for activities and lesson plans from the Internet, but had to modify the lesson plans according to guidelines established by the NRC (2000). Qualitative codes were developed from open coding of data (Strauss & Corbin, 1990) and comparison against both the NRC’s framework of inquiry (NRC, 2000) and Bell et al.’s (2005) classification of inquiry. Qualitative analysis of data revealed that participants demonstrated using of the five features of inquiry (NRC, 2000) as teachers of science, teacher-directed inquiry instruction, discrepancy in interpreting the amount of guidance from teachers, and adaptation of inquiry instruction during enactment. The results for Research Question 2 are listed in Figure 2 (with theoretical codes italicized) and explained in detail in the following narrative.

- Teachers using five features of inquiry (NRC, 2000)
  - Teachers asking scientifically-oriented questions
  - Teachers interpreting data as evidence
  - Students collecting data
  - Teachers analyzing data as evidence
  - Teachers explaining results of activities
  - Teachers connecting activities to scientific knowledge
  - Teachers communicating and justifying results of activities

- Teacher-directed inquiry instruction (Bell et al., 2005)
  - Teachers presenting questions
  - Teachers providing procedures

- Discrepancy in interpreting enactment of inquiry instruction
  - Discrepancy in interpreting levels of inquiry
  - Discrepancy in interpreting teacher-guidance during inquiry

- Addressing adaptation of inquiry instruction
  - Including adaptation of inquiry instruction in both lesson plans and during teaching

Figure 6. Theoretical codes and emergent codes for Research Question 2: Preservice special education teachers’ enactment of inquiry instruction in the context of a science methods class (with theoretical codes italicized).
Using Five Essential Features (NRC, 2000) as Teachers of Science

In their microteaching, participants used all five essential features of inquiry (NRC, 2000) as teachers of science. The five features as listed by the NRC are that learner engages with scientifically-oriented questions, learner gives priority to evidence, learner formulates explanations from evidence to address scientifically-oriented questions, learner evaluates his/her explanations in light of alternative explanations, and learner communicates and justifies explanations (NRC, 2000). Aligning with these features, participants as teachers of science during the microteaching asked at least one scientifically-oriented question to initiate inquiry investigations, engaged their peers (posing as students) in data collection, explained results in terms of collected evidence, evaluated alternative explanations and communicated, and justified results of inquiry investigations in terms of evidence. Participants submitted a lesson plan describing in detail their inquiry instruction, and these plans were organized according to the components of the Learning Cycle model (Bybee, 2000). The five components of the Learning Cycle model (Bybee, 2000) are Engage, Explore, Explain, Extend, and Evaluate. During the 20-minute microteaching assignment, candidates had to demonstrate an understanding of the five features of inquiry. Considering the broad similarities in enactment across all groups, I present data from the first group (Paula and Brian) to illustrate the primary themes first and then use data from additional groups to elaborate on additional themes.

The following is an account of how the first pair of study participants enacted their inquiry instruction during microteaching. Brian and Paula taught a third grade
science lesson on sources of fresh water on earth using “A Drop in A Bucket” developed by the Utah State University Water Quality Extension (2012). The teachers modified the retrieved lesson plan according to the guidelines of the assignment and taught the lesson to their peers during their inquiry microteaching. The scientifically-oriented question that guided this group’s inquiry investigation was, “If the [5-gallon] bucket represents all the water on earth’s surface, how much water is drinkable?” (Inquiry Microteaching Video, Brian and Paula). Brian and Paula asked students to look first at a globe and identify sources of water on earth. They asked students to predict percentages of water in identified sources (e.g., oceans, lakes, rivers, etc.). Then, students had to measure out the predicted amounts of water in various sources from the bucket of water (representing all water on earth) using measuring cups, spoons, and droppers. The measurement activity constituted students collecting data toward answering their inquiry question. But, following the measurement activity, the instructors analyzed the collected data for the students and connected the demonstration to the science content. Brian briefly asked students to share their results from the data collection. Instead of allowing students to do the calculations, however, Brian wrote down actual amounts of water found in different sources, calculated percentages as he moved from source to source, and finally explained the results that less than 95% of earth’s water is drinkable. Brian and Paula, as science instructors, also extended the learning to other situations, informing students about the importance of conservation of water and finally justifying the results in terms of evidence. Brian and Paula, as teachers of science, did use all five features of inquiry (NRC, 2000), and thereby enacted a teacher-directed inquiry. Their inquiry
microteaching lesson plan was also organized according to the components of the Learning Cycle model (Bybee, 2000). This trend reoccurred in all groups where participants as teachers of science used the five features of inquiry (NRC, 2000).

**Enacting Teacher-Directed Inquiry Instruction**

The teaching videos also repeatedly revealed enactment of teacher-directed inquiry instruction in the study participants. While all groups allowed students to collect data, the sense-making of collected data as evidence was primarily done by the teachers themselves. Participants as teachers analyzed the data, tied results to the inquiry questions and justified results in terms of evidence. Moreover, teachers did all the extension components, informing students how such learning could be applied to contexts other than the immediate context of the activity. As with the first group, following data collection by students, Brian and Paula informed students of the actual amounts, compared various sources of water and explained that less than 97% of earth’s water is drinkable. Thus, even if students did take part in the data collection, instructors interpreted the data in terms of evidence. This was also found in all other teaching videos, where students involved themselves in the activity and collected some data, but the instructors themselves conducted the analysis and interpretation of data. This type of inquiry instruction differs from the NRC’s (2000) concept of inquiry where learners develop explanations from evidence, connect explanations to other science content and communicate and justify these explanations.

Rating their inquiry lessons according to classification procedure developed by Bell et al. (2005), most inquiry lessons consisted of confirmation labs where teachers
provided questions, procedures and solutions. Only one (Francine’s group) exhibited a structured inquiry where teachers provided the question and procedures but allowed students to find out the solution. Two groups (Jack and Mike; Holly and Ida) exhibited guided inquiry where teachers provided the question but allowed students to develop the procedures and come up with the solution. Reenactments of some of the groups’ presentations follow.

In Brian and Paula’s group, as described earlier, participants addressed the teacher-initiated research question: If a 5-gallon bucket represents all the water on earth’s surface, how much water is drinkable? While students looked at the globe and identified the sources of water on earth and predicted percentages of water in these sources, Brian analyzed data in terms of evidence, telling the students about actual amounts, comparing actual amounts with predicted amounts. Brian extended and justified the results in terms of evidence, and did not allow students to draw their own conclusions, thereby exhibiting a confirmation inquiry lab.

The second group, Kim, Carol, and Emily, exhibited a confirmation lab type of inquiry lesson. Kim’s group did a first grade science lesson on physical change involving making ice cream in a Ziploc bag. Here, Kim first asked students: “Do you think we can make ice cream with these materials? We will see.” The question turned their inquiry lesson to a confirmation lab since students almost knew in advance that they would be making ice cream. Teachers gave verbal step-by-step procedures which the students followed (first adding milk in the small Ziploc, then adding measured amounts of vanilla and sugar to the milk, then putting the sealed bag inside a larger Ziploc, then adding ice-
cream salt to the larger Ziploc and finally gently shaking the bag) and students then observed the milk freeze. Following the completion of this activity, Kim’s group described how milk changed from a liquid state to solid state by freezing and explained how this constituted an observable physical change. Thus, rather than students, teachers provided all three pursuits of learning—asking questions, developing procedures, and providing solutions, thereby making the lesson a confirmation lab.

Holly and Ida enacted a different type of inquiry lesson while teaching their students about bird’s habitat. The instructors provided the inquiry question, “What kind of nests can you make using the materials on the table?” Students did not receive any step-by-step procedure but used a variety of methods to build a nest with the materials provided (dirt, soil, water, twigs, pieces of yarn, etc.). This was a challenging activity since some students had trouble building the nest with the provided materials. Following the activity Holly and Ida explained: “So—do you realize how much efforts birds undertake to build a nest?” and later added, “I just want you to appreciate how hard it is—and they don’t even have beaks.” Here, the students formulated their own procedures and were guided by a scientifically-oriented question. They had the question as they worked and presumably generated some meaning as they did the activity, but the teachers stepped in and provided the explanations in the end.

Francine’s group chose to plan a structured lab (Francine’s partners did not take part in the study) with a fourth-grade science lesson on physical and chemical change in matter. The lesson involved blowing up a balloon with carbon dioxide gas produced by the reaction between baking soda and vinegar in a bottle. First, the teachers explained
physical and chemical changes using a PowerPoint containing real life examples of physical change and chemical change, but they then introduced the activity to allow students to explore some physical changes and chemical changes first-hand. Students had to predict what would happen if vinegar and baking soda should be mixed and followed instruction to observe the results. Following the activity, students recounted any changes they observed in the activity and asked if they could identify the type of physical change and provide reasons for their identification. Here are two excerpts from their video analysis: (T represents teachers, S indicated student)

**Instance 1:**

T: So tell me—what was one physical change that you observed in this experiment?

S1: The balloon.

T: The balloon what?

S2: It blew up.

T: Yes. The increase in size of the balloon. That was a physical change.

**Instance 2:**

T: Think for a moment, tell me what are some characteristics of a chemical change?

S: It can’t go back.

T: Yes. It can’t go back.
While teachers provided considerable guidance, I rated these lessons as structured inquiry since students were given the opportunity to discover the answers by gathering and interpreting evidence following the teacher providing the initial research question.

One group that exhibited a guided inquiry was Mike and Jack since they allowed students to develop their own procedures. Jack and Mike taught a second-grade science lesson on Force and Motion, involving students to move a Ping-Pong ball in many different ways. The instructors provided relevant materials to each small group and began their inquiry instruction with the question, “How many ways can you move the Ping-Pong ball from one end of the table to the other?” Students developed their own procedures to move the ball using materials like string, tape, drinking straws, cardboard, yardsticks and rubber bands. Following this initial exploration, Jack and Mike posed follow-up questions such as, “How do you think you can slow down the ball?” and “Can you make it speed up?” and allowed students to use their own methods to explore the possibilities. Upon completing explorations, Jack and Mike asked students to list some ways they made the ball move, slow down, or speed up. As the students replied: “We pushed it,” “We rolled,” “We hit,” “We spun the ball,” instructors wrote the word on the board that best represented a force (e.g., “push,” “roll,” “hit,” “spin”). Afterward, Jack asked, “So what was common to all these terms?” to which students responded that they made the ball move. Jack then asked students, “Do you know what these represent?” and the students responded “Force” (Inquiry Microteaching Video, Jack and Mike). Jack next explained that these were all examples of force that made the ball move and further explained how some forces allow moving objects to speed up or slow down, tying
content to the students’ own activities. Despite this debriefing, however, he first had allowed students to identify forces that made the ball move, thus allowing students to develop their own explanations to the scientifically-oriented question. Although scaffolded with several guiding questions, this group’s inquiry instruction was a guided inquiry lab since students did not develop their own questions but proposed solutions after developing their own procedures.

In sum, all the participants mostly enacted different types of inquiry instruction; some were more open than others. Participants as teachers rarely allowed students to come up with explanations of their inquiry investigations. Instead, students were seldom given the chance to collect data and further less chance to make sense of the data as evidence, a crucial feature of inquiry.

**Discrepancy in Interpreting Enactment of Inquiry Instruction**

A significant discrepancy appeared in the participants’ ratings of their own inquiry lesson compared to my own ratings. I rated participants’ enactment of inquiry according to the rubric provided by Bell et al. (2005), who classified inquiry into confirmation labs (level 1), structured inquiry (level 2), guided inquiry (level 3), and open inquiry (level 4). Except for three participants (Francine, Holly, and Ida), all other participants assigned their inquiry lesson at least one level higher than my own rating. One group (with Emily, Carol, and Kim) exhibited a two-level discrepancy, where they enacted a confirmation lab (Level 1) according to my rating, but interpreted their enactment as guided inquiry (Level 3). None of the participants who enacted a confirmation lab type inquiry instruction interpreted their inquiry instruction as a
confirmation lab. The discrepancy was highest for Emily’s group who enacted a confirmation inquiry, but considered the enactment a guided inquiry lesson. Participants in this group, as teachers, provided step-by-step instruction to their students using guided questioning, which made me consider their enactment a confirmation lab. Here is an excerpt from the video analysis that reflects teachers providing procedures to students:

T: So do you think we can make ice cream with these materials? What do we need?

S: The milk.

T: Right. Where does the milk go? Now pour the milk in the small Ziploc bag. What do we do next?

S1: Add sugar.

S2: Add salt.

T: Do you think we should add the salt to the milk? Is ice cream sweet or salty? It’s the sugar. Go ahead; now add the sugar to the milk. Add 1 spoon of vanilla too. (Inquiry Microteaching Video, Kim, Emily, and Carol)

All three participants in both their reflection papers and interviews indicated that they used a guided inquiry, reasoning that they did not provide step-by-step instructions to their students. “We did not give [students] any steps, so it is a guided inquiry” (Kim, interview) was a common sentiment also found in Emily and Carol. While participants should understand that guided inquiries involve students developing their own procedures, participants interpreted their own provision of procedures differently from guidelines outlined in Bell et al. (2005). As for Kim’s group, the teaching videos indicate
that the group provided step-by-step instructions to their students to make ice cream in Ziploc bags. Clearly, these participants believed that a high level of guidance from the teacher was necessary to accomplish learning in an inquiry lesson. There are two possibilities why participants felt this way. Either they did not realize that they had provided a step-by-step procedure (misunderstanding their own lesson), or participants as teachers thought that providing a step-by-step procedure was actually consistent with a guided inquiry approach (misunderstanding inquiry). The amount of data was not enough to distinguish between these two possibilities.

Another disconnect appeared in Kim’s groups’ lesson planning when they extended their inquiry activity to other situations. This group was found to repeat learning cycle components (Bybee, 2000) during their enactment of inquiry. For example, following their ice-cream-making activity, Emily’s group asked students to take a piece of paper, crumple it, and observe the similarities and differences between the plain paper and the crumpled paper. Through guided questioning, Emily’s group elaborated the concept of physical and chemical change, drawing an analogy with the crumpled paper. They indicated that ice cream bore similarity to milk as a crumpled paper bore similarity to the plain paper; the same material took a different physical form. While this can be considered as an Extension component of the Learning Cycle (Bybee, 2000) where instructors apply learning to other situations, these participants used this activity as a way to explain the activity. They included this analogy in the Explain section of their lesson plan, indicating that they explained the activities in two ways—once using a PowerPoint with terms and definitions and again using the paper crumpling
as an analogy. During the interview, both Kim and Emily indicated how they twice used explanations to go over concepts. This type of enactment differed from that of the NRC (2000) guidelines of inquiry instruction and could possibly stem from participants’ own unique interpretation of inquiry.

Additionally, two groups (Adam and Gail, Brian and Paula) had co-teachers interpret the same inquiry lesson differently. Gail and Adam, who taught a photosynthesis lesson using a simulation lab, interpreted the same lesson differently. Gail considered the lesson to be structured, recognizing that she had provided step-by-step procedures to students, and she indicated in her interview, “I think probably the structured because we gave them the steps for the simulation.” But Adam considered the lesson to be as guided inquiry, believing that he had not provided any step-by-step directions in two data sources—the reflection paper and the interview: “We also made the level of inquiry a guided lesson. This means that the lesson is guided, but the students will work through problems on their own” (Adam, Inquiry Microteaching Reflection). When I asked Adam why he considered his lesson to be guided inquiry, he answered.

Like we just said, here, you guys, do this. And then they take over the controls.

Like we would give them what the controls were so they would know what each button did, but at that point it was up to them to decide. (Adam, interview)

Giving instructions regarding the experimental controls of the simulation lab did not translate as providing step-by-step instruction to Adam, although I see this as providing step-by-step directions to students. A similar discrepancy was found with Paula and Brian. While Paula considered her lesson to be a structured inquiry, Brian considered his
lesson to be a “hybrid inquiry lesson” that was “somewhere between structured and guided inquiry,” since “the first part of the lesson involved giving instruction,” and the exploration part involved students formulating their own steps. Brian thus likewise interpreted the role of giving instruction during inquiry lessons differently from what Bell et al. (2005) stated.

**Addressing Adaptation of Inquiry Instruction During Enactment**

A small number of participants provided modifications of their inquiry lesson to fit diverse learners in the classroom during their actual teaching. While addressing adaptations to accommodate diverse learners was a required component in their lesson plans, no such elements were required to be addressed during their microteaching. Some participants, however, addressed adaptation during the actual microteaching in addition to describing accommodations in their inquiry lesson plans. In one example, Francine’s inquiry lesson that involved blowing up a balloon with carbon dioxide opened by asking if any of the students possessed an allergy to latex. Francine’s group recognized that all materials used during hands-on inquiry activities might not be suitable for all learners. Despite such recognition, Francine’s group did not provide any modification strategies that would work for students with a latex allergy.

Two other groups not only identified components that can be sensitive to learners in the inquiry environment, but also suggested modifications towards such issues. An example is Holly and Ida’s lesson on Habitats that involved students constructing nests using natural materials like twigs, dirt, and water. As observed in their teaching videos, their group addressed that if certain learners with special needs became uncomfortable
with touching the materials such as dirt and water, they would ask them to draw a picture of the nest. Another group, Gail and Adam, addressed differentiation in their extension activity with their lesson on Plants using a Jeopardy Game. In that lesson, questions in the activity could be adapted according to the needs and levels of the students. These participants not only included adaptation strategies in their lesson plans, but also included them during the actual teaching as evident in the teaching videos. This is evidence for how these preservice teachers brought their special education background with them while teaching science using inquiry in the methods class context.

**Summary of Results for Research Question 2**

Analysis of participants’ enactment of inquiry instruction in the context of their science methods class indicated that all of the study participants exhibited some form of teacher-directed inquiry. While such a demonstration can indicate a stronger understanding of the gradations of the five essential features of inquiry (NRC, 2000) as teachers of science, this instruction also provides fewer opportunities for meaning-making of evidence for their students (Anderson, 2002; Crawford, 2007). Participants, as science teachers, did assume an active role in the observed inquiry classrooms: They were asking scientifically-oriented questions, providing procedures, developing explanations, extending learning, and justifying explanations to their students; the role of students was mostly limited to following instructions. This type of instruction does not embody the idea of a student-centered learning as encouraged by the NRC (2000) since learners did not involve themselves in interpreting data as evidence or building scientific explanations from evidence. In addition to this, the participants interpreted their
enactment of inquiry instruction differently than how I did using Bell et al. (2005). They not only assigned a level to their instruction that was different (higher) than my own rating but interpreted differently the amount of guidance provided by the teachers from what is found in science education literature (e.g., as in Bell et al., 2005). Nonetheless, even though observed in some but not all participants, studied teacher candidates addressed adaptations of their inquiry instruction for diverse learners during their inquiry teaching. These results make me assert that participants struggled with understanding the student-centered aspect of inquiry instruction. The results indicate that some of these teachers applied their special education background while teaching science using inquiry instruction and interpreting their own enactment.

**Findings to Research Question 3: Views on Inquiry Instruction**

The third research question investigated preservice special education teachers’ views about teaching using inquiry instruction. While participant interviews remained the primary source of data for this research question, other sources (post-questionnaires and inquiry microteaching reflection papers) provided information for this question. The main emergent themes for this research question are: *Inquiry works for all students—including students with disabilities, inquiry is beneficial to students and teachers, inquiry has challenges in the special education context, inquiry needs adaptation for diverse learners, certain factors influence views and this class as a first inquiry learning experience.* Once again, these themes arrived from several theoretical codes (comparison to inquiry perspectives from NRC, 2000) and emergent codes (appearing from open coding of data) that had been generated from my qualitative analysis. The results of
Research Question 3 are outlined in Figure 3 (with theoretical codes italicized) and described in the following narrative.

- **Applicability of inquiry**
  - Works for all students, including students with disabilities

- **Benefits of inquiry-based teaching**
  - **To students**
    - Promoting understanding and engagement
    - Teachers guide understanding of hands-on experiences
    - Enjoyment by hands-on experience
    - Sensory experience
  - **To teachers**
    - Promoting planning of instruction
    - Providing reinforcement of learning
    - Increased scope for inquiry

- **Challenges in special education context**
  - **To students**
    - Shorter attention spans
    - Lower cognitive levels
    - Disability a barrier to learning
    - Behavioral Issues
  - **To teachers**
    - Diversity in needs a challenge
    - Identifying need a challenge

- **Adaptation of inquiry**
  - Inquiry needed to be adapted for some learners
  - Inquiry can be adapted
  - Adapting inquiry features
    - Adapting questions
    - Adapting hands-on experiences

- **Constructs influencing views**
  - Previous science experience (this course as first experience of inquiry learning)
  - Perception of own learning style
  - Previous experience in special education

*Figure 7.* Theoretical codes and emergent codes for Research Question 3: Preservice special education teachers’ views on teaching using inquiry (with theoretical codes italicized).

**Applicability: Inquiry Supports All Students, Including Learners With Disabilities**

The view regarding the applicability of inquiry instruction appeared as an emergent theme from the open coding of data (Strauss & Corbin, 1990) of the interview transcripts. Each participant articulated that inquiry instruction supported all students,
including learners with disabilities. Despite this, six of the participants specifically emphasized that inquiry instruction needed to be adapted for students with disabilities. Taking a closer look at the views, I noticed a dichotomy in their perspectives as some of the participants viewed the benefits from the student’s standpoint, while others viewed benefits from the teacher’s standpoint. Some key examples of these two types of views are presented below.

Kim and Brian both indicated that inquiry worked for all students, including students with disabilities. Kim expressed her thoughts in the following way:

I think it is good for everyone. I think a lot of the things that work for special education are great for general education classroom too. I know that I don’t learn best through lectures. I know I learn best with hands-on experiences. So I think it would be great for everyone. (Kim, interview)

Here, Kim believed that inquiry promoted learning by hands-on experience, which she felt worked for all students. Kim conceptualized inquiry as a hands-on learning experience that differed from learning by lecture, which she preferred as a learner. She also held that this type of hands-on learning was beneficial to both general science students as well as students with disabilities since she felt that strategies in special education worked in general science classrooms as well. In a later part of the interview she indicated, “I believe that methods that are just for special education can be applied to every single student.” Kim’s view of applicability of inquiry instruction thus included two beliefs—one, that inquiry worked with all students with or without disabilities, and two, that students benefited from such hands-on learning. I included Kim’s belief about
applicability here first, and elaborated on her thoughts on usefulness of inquiry under the
*Benefits to Students* section since she perceived the benefits of inquiry from the learner’s
perspective.

On the contrary, another participant—Brian, who also considered inquiry to be
“transcendental” and “cross-categorical” in nature, thought so from a different
perspective.

I think it makes sense to both kinds of students. It makes sense for both typical
learners and atypical learners. It is just a good format; a good foundation to
follow. And it gives the instructor a game plan too. (Brian, interview)

With this, Brian believed inquiry to give a good format for *teachers* and felt that teachers
could take inquiry and apply this method to teach other subjects. Thus, Brian’s view
appeared similar to Kim’s in that he also felt inquiry instruction worked for all learners,
but his perspective differed because he felt the *teachers* could apply this instruction while
teaching other subjects and thus reaching all learners, a perspective not found in Kim’s
viewpoint. Here I focused on Brian’s view of applicability in this section but elaborated
on his thoughts of usefulness of inquiry under *Benefits to Teachers* section, since he
perceived the benefits of inquiry instruction from the teacher’s perspective.

A third participant, Carol, indicated during the interview that “[inquiry] can work
in any context as long as you modify it” (Carol, interview). This differs slightly from
either Brian or Kim’s viewpoint. Since Carol’s view identified the need for adapting
inquiry, I listed her views about applicability of inquiry instruction here and have
expanded her views further under the *Adaptation* section. Thus, from the applicability
perspective, the participants’ views branched into three directions—benefits (to either students or teachers), challenges (in the context of special education), and adaptation of inquiry.

**Benefits of Inquiry**

Several participants identified the benefits of inquiry instruction either from the learner’s perspective or the teacher’s perspective. While more participants considered learning by inquiry beneficial to *students* in a variety of ways, few indicated that teaching using inquiry benefitted *teachers* in certain ways. The main images of such benefits are described below.

**Benefits to students.** A majority of my study participants indicated that inquiry learning promoted students’ understanding and engagement in science.

*Promoting understanding of science concepts.* The first benefit to students associated with inquiry-based learning as identified by my study participants was inquiry promoting an understanding of science concepts by incorporating hands-on learning. Fourteen of the 16 participants (all except Jack and Olivia) indicated directly in the interview that inquiry learning promoted understanding in students, as illustrated below.

Ida suggested that inquiry learning worked for students since this supported thinking in learners. She explained, “I think that [inquiry learning] is essential because it gives them a deeper level of thinking and understanding of the way things work and the way people find out information.” She soon added:

I think [inquiry learning] is really good in this day and age because . . . it’s good for them to stop and take a minute to think you know—anything with this science
now they can ask their phone. But [inquiry] gets them to realize that people had to actually figure this information out and this is the process and this is the kind of process you go through to get to that information. (Ida, interview)

Here, Ida conceived that inquiry-based learning allowed students to learn concepts by encouraging them to reflect, think and make sense of their experiences and saw the value of such a learning experience. Ida identified that students doing something and reflecting on their experiences, thinking how they came about the results of an inquiry activity, was valuable to students since inquiry promoted critical thinking.

Gail provided a similar view as she felt that inquiry learning encouraged critical thinking in students. Gail expressed her thoughts in the following way:

I think [inquiry] is engaging and that it supports [students’] understanding. It’s more than a method of teaching. It’s something that—it does not have them recall facts but try to dig into the topic and let them find their own answers. It’s just a lot more effective that they can come up with their own questions and be able to support your reasoning. (Gail, interview)

Gail believed inquiry allowed critical thinking in students by prompting them to make sense of evidence instead of meaningless recalling of information. Gail considered inquiry to involve thinking about concepts through questioning and searching the answers and supporting the answers with reasoning. Gail’s views matched to some extent with the image of inquiry conceptualized by the NRC (2000), since the NRC recognized that students learn by asking questions, looking at evidence and justifying their answers in terms of evidence.
Five more participants perceived that inquiry involved learning by interpreting evidence, and such an approach facilitated understanding in students. For instance, Kim explained that a hands-on approach during inquiry-based teaching works better than lecture methods since students connect better to concepts via first hand, direct experiences:

I think it definitely works. Like any time you do hands-on activity rather than a lecture, especially with students with moderate to intense special needs. I think it is easier to connect to it. Like connect to an idea when you get to experience it hands-on and get to see it firsthand instead of just listening about it sitting there.

(Kim, interview)

This reveals Kim’s belief that inquiry-based learning, which allowed students to experience concepts first-hand rather than learn about science concepts from listening to lectures. Kim felt that this type of hands-on learning allowed students to understand concepts via direct, authentic experience, a thought also embedded in the NRC’s (2000) vision of inquiry.

Another participant who held a similar view was Debra, who expressed her thoughts in the following way: “I really like the looking for evidence part because it gives something.” She added directly, “To figure things out, having the things find out for themselves, discover those—I think they better sticks with you.” Debra also indicated that students with disabilities may need additional support from teachers to accomplish learning via inquiry: “I just think that you just have to guide them more.” Here, Debra believed that students looking at evidence made concepts more tangible, which facilitated
understanding in students. She further stated that inquiry allowed students to discover things for themselves, which helped with learning retention.

Another participant, Emily, also expressed a similar position as Kim and Debra. Emily indicated that “looking at evidence would be a big thing for these kids because they can concretely be able to see things that would help them in their learning.” Similar to Kim and Debra, Emily felt that making sense of the evidence during inquiry helped students to understand the concept by making it more tangible. She also felt that gathering data and interpreting evidence allowed students to experience science first-hand, which may support learning in students with disabilities.

As a result, all these participants indicated in various capacities that inquiry proved beneficial to students, as it promoted their understanding of scientific concepts. Only two participants (Olivia and Mike) did not indicate “inquiry promoting understanding” in their views during inquiry. But Olivia referred to understanding even if she did not use the term “understanding,” felt “the figuring-out-why part is important [sic]” because:

If you have a student just read. . . . So when you say—’when you do this, this happens’, ‘this happens because of this’ (boring tone), they are not going to make connections to it . . . They at least would have been able to do that connection.

Seeing what is happening supports their learning. (Olivia, interview)

Olivia conceptualized inquiry as a hands-on learning process in which students take part in first-hand experiences and reflect on such experiences rather than assume a passive role of listening to lectures or engaging in mindless reading. She instead believed that
inquiry learning allowed students to engage in and reflect on direct experiences, which promoted better student comprehension.

The other student, Jack, a Moderate to Intense major who did not explicitly state that inquiry promotes understanding in students, believed that students with disabilities may actually struggle to understand concepts via inquiry. He noted, “If you have a student that’s severely disabled, he or she may not be able to understand the concept.”

Jack was the only participant who identified in the interview that some students might not be able to understand meaning behind the activities. This view takes understanding by inquiry learning in a new direction when being applied to students with disabilities. While several participants indicated that inquiry allowed hands-on experiences and that these experiences helped students to understand concepts, such understanding can be difficult for certain learners with disabilities.

**Teachers facilitating understanding of scientific concepts.** While the above participants recognized that learning by inquiry promoted understanding in students, several of them indicated that teachers played a significant role in guiding students toward their (student’s) understanding. Some key examples follow.

**Teachers asking questions to guide understanding.** Several participants indicated that teachers needed to use questioning to guide students’ meaning-making of experiences. For example, Paula, an early Childhood Intervention major, believed that inquiry definitely worked for young children. When I asked why she believed this, she responded, “Because this is how children learn.” She further elaborated, “I know like in the preschool program, it is asking questions, kind of keeping the children engaged,
Paula believed that teachers’ questions promoted both engagement and understanding in students. In another part of the interview, she mentioned, “I think with special ed students, if you are not guiding them or asking them questions, you are just like stuck rather than extend their learning.” While this again may be little different from how the NRC (2000) conceptualizes the Questioning feature of inquiry, according to Paula, teachers’ guiding students’ learning is a valuable part of inquiry instruction because it helps to expand students’ understandings of the material.

Her teaching partner, Brian, also contended that questions allowed teachers to assess prior knowledge and guide students’ thinking during inquiry. “I think [inquiry] makes sense,” said Brian in the interview. “With questions—asking questions, giving questions, recalling their prior knowledge through these questions. It kind gives a clear cut way to get your students into your vein of thought.” Here, Brian indicated that teachers’ questions not only assess prior knowledge in learners, but also provide students with some direction in their thinking to facilitate their understanding. While this type of teacher questioning is dissimilar to the Questioning feature in the NRC (2000), Brian considered this to be a reason why inquiry worked with students.

 Teachers explaining. Several of the study participants believed that teachers needed to explain inquiry activities to students to scaffold their sense-making of the hands-on experiences. Olivia, an Early Childhood Intervention major, exemplified this by stating, “You know, the explaining findings part of inquiry is important and backing it up—the investigations, that’s what is more important.” She added:
They at least would have been able to do that connection. We could have always said—what does that remind you of? To see this says this—you know, what did you see? Seeing what is happening supports their learning. (Olivia, interview)

Here, Olivia indicated that teachers needed to scaffold the meaning-making in students using guided questioning. She felt that this allowed students to better connect with the concepts being taught by prompting them to think about it. Earlier, she indicated that inquiry instruction was better than lecture, which involved the mindless transmission of information to students. Thus, Olivia indicated that inquiry was good for students, since students engaged in hands-on experiences, but teacher-guidance was also essential to scaffold the meaning-making during inquiry.

Two participants, Jack and Emily, believed that explanations by teachers after inquiry investigations supported understanding of concepts during inquiry. During his interview, Jack stated:

Some may not be able to grasp [the concept] because of the information, the content, as you are teaching them the content. That’s why you really need to explain and elaborate. You know, you got to do these things afterwards. That would be so much better. Like the whole—you know. Like you are going to think if they are really going to grasp the concept, and inquire for themselves. Or try to be more involved. I think that is a question you have to ask yourself. (Jack, interview)

Here Jack conveyed that teachers explaining content after explorations allowed learners to understand the concept clearly during inquiry. While this is again somewhat different
from the NRC’s (2000) *Explain* feature, Jack considered this to be a part of effective inquiry instruction.

Another participant, Emily, also believed that teachers explaining inquiry activities supported meaning-making of concepts in students, but viewed inquiry from a different perspective. She articulated that “explaining it to them is important. It’s like really making sure that they understand every detail and part of the lesson, so I think explaining it to them wide over and [do it] repeatedly.” With this, Emily felt teachers’ explanations here provided learners repeated opportunities to deliver content with such repetitions promoting understanding in students. While this differs from the *Explain* feature of inquiry in the NRC (2000) where learners generate evidence-based explanations, Emily felt that explanations by the teacher following classroom exercises reinforced what students had learned. Emily considered that this was one of the ways teachers ensured meaning-making during inquiry learning in students.

*Teachers extending.* A few of the participants used the *Extension* feature of the Learning Cycle (Bybee, 2000) to explain how teachers scaffolded students’ understanding of science concepts during inquiry-based instruction. In one example, Francine indicated that, “the extend-and-apply-to-other-situation is important.” She further explained:

Probably because a lot of special education is focused on generalizing their knowledge and their skills. So it’s like—you couldn’t get off the example of the water freezing. That’s a very basic concept. So knowing this basic concept like water freezes will help them learn in other places. Like in their house—they may
be drinking cold water or make ice cubes. That’s not just a practical example; that’s also scientific in nature. (Francine, interview)

This sentiment indicated how Francine believed that extending concepts by teachers beyond the immediate context of activities and applying learning to other situations supported meaning-making in special needs learners.

In all of these cases, participants indicated that teachers used certain components of inquiry (NRC, 2000) or the Learning Cycle (Bybee, 2000) to guide understanding in their students during inquiry. While many of their characterizations are somewhat different from theoretical conceptions of inquiry (NRC, 2000), these participants considered these elements to be parts of effective inquiry instruction. These views create almost a dichotomy in participants’ views on students’ understanding by inquiry. While some recognized that hands-on experiences promoted understanding in students, some also considered that teachers play an extremely active role in facilitating the meaning-making of such hands-on experiences, often providing the explanations of these experiences to students. These findings make me posit that while participants recognized the benefits of inquiry instruction as conceptualized by the NRC (2000), they, being prospective teachers in special education, strongly incorporated the role of teacher-guidance into their interpretation of inquiry-based learning.

**Engagement and enjoyment in learning.** The participants indicated that inquiry learning brought them a sense of engagement and enjoyment while learning science. Two participants provided good illustrations of this view, though all of my study participants espoused this position. Mike, a Moderate to Intense Educational Needs
major, felt that inquiry experiences supported learners with disabilities by promoting both understanding and enjoyment:

I think it works really well because instead of the teacher standing up and lecturing and telling you what it is. One, it’s a lot more fun—instead of the teacher standing up lecturing and giving the answers, it gives the students the chance to explore their own and develop their own meaning behind it—a concept or a topic. And two, it sinks in more I think because they have that hands-on experience. (Mike, interview)

In this statement, Mike recognized a number of benefits associated with inquiry. According to him, inquiry “was fun” and the hands-on experiences incorporated enjoyment in learners. Moreover, when students have a chance to explore science concepts via hands-on experiences, they take part in their own learning. These views resonate with images of inquiry held by the NRC (2000), and Mike, as a prospective teacher in special education, perceived the same value to learners with disabilities.

Gail, an undergraduate Mild to Moderate Educational Needs major, likewise identified the role of fun in learning by inquiry. According to Gail, inquiry learning worked for all students, with or without disabilities. When asked why she thought so, she responded:

This would be engaging. With the students that I have worked with and done kind of like science labs with, there was a while where they get to be the owner a little bit. Be able to be more excited with it and deal with it. They want to know the answers. And for some with the behavioral needs, it keeps them engaged and
they can get their hands dirty and they are allowed to and it is really fun. (Gail, interview)

Here, Gail identified a number of benefits of inquiry for students. She considered that inquiry not only incorporated engagement and enjoyment in learning science but that it also enhanced motivation in students that developed from a sense of ownership during inquiry-based learning. Once again, the views she harbored match with the views of NRC (2000); however, Gail conceptualized them from a teaching-students-with-disabilities-perspective. Gail was also one of the participants who indicated that inquiry instruction worked for all students, including students with disabilities.

**Providing students with sensory experiences.** At least eight (Debra, Mike, Jack, Olivia, Holly, Paula, Ida, Emily, and Carol) participants indicated that inquiry provided a sensory experience to learners that might help promote their understanding of science concepts for students with disabilities. The following are key examples:

Mike, during the interview, expressed that inquiry instruction *may* work with students with disabilities. Mike explained:

> A lot of students with special needs have a lot of sensory needs. So being able to pick things up and feel them in their hands and get the feel for what the item is or what—what texture is—is something really—it can almost be therapeutic for students. (Mike, interview)

Mike not only felt that inquiry allowed multiple sensory experiences, but he also believed that such experiences benefitted students with disabilities, because it allowed them to experience the concept using multiple senses. During his microteaching, Mike provided
a variety of materials of different shapes and textures to his students and allowed them to engage in hands-on explorations of these materials.

Carol harbored a similar viewpoint as Mike and said, “Especially for kids who need, that have sensory needs, hands-on activities would be really good.” She further explained,

Because I feel like it is a lot easier to learn when things are hands-on. And if you don’t necessarily understand the content, or if you are little lost, like if you are can see it and make it happen in front of you, it makes a lot easier to learn it and understand it. (Carol, interview)

With this, Carol believed that students observing science demonstrations made concepts easier for them to understand. Although Carol’s view also incorporated a sense of learning by reinforcement, Carol’s views about observing to improve understanding is important to recognize. Her group’s activity included the use of multiple senses, as they taught an inquiry lesson on physical and chemical change involving making ice cream from milk in Ziploc bags. In this activity, they prompted students to see milk freeze to solid form and also observe the change in temperature by touching the bag. This leads me to believe that Carol found that inquiry imparted a sensory experience to learners.

Holly also held a similar position about inquiry learning involving using multiple senses. “You have to experience it in the senses,” Holly reflected during the interview. She noted, “It has to have some kind of meaning in their world otherwise it’s you know, I’ll end up with kids who are completely turned off or frustrated.” Holly’s group’s microteaching lesson on Habitat provided a variety of natural materials (dirt, soil, water,
twigs) to students to build a bird’s nest. Reflecting on her inquiry teaching, Holly indicated, “We had a lot of tactile materials as well that related to all the senses—we had a lot of inquiries about your senses.” Carol encouraged students to explore nest-building using multiple senses—observing and touching the materials. She felt that such an activity allowed students to understand how difficult it was to build a nest using natural materials. “I think the groups were liking it, but it was just really hard. Like I didn’t know how hard it was to build a bird’s nest.” She conveyed that hands-on exploration of nest-building using multiple senses allowed learners to better understand the concept being taught.

Like the above participants, Debra indicated during her interview that being able to use the senses was an important part of inquiry learning. Her group taught about the pressure-dependent nature of matter using a cornstarch and water mixture. They allowed students to play with the mixture in a variety of ways—seeing the texture and using fingers to touch the material and feel the texture as found in their teaching video. She indicated during the interview that “the most important part of [the activity] was that [students] got to see for themselves what that substance felt like—when they took on the different stages.” A similar theme in her reflection paper, “manipulating and observing the quick-sand” (Debra, Inquiry Reflection Paper) proved an important part of students’ exploration during her microteaching. In sum, Debra also recognized that inquiry learning provided sensory experience to students, which supported their understanding.

Another participant, Paula, believed that inquiry worked better than one-way transmission of information. She explained, “They are better because if you are a hands-
and-brain learner, you are very visual and you are hands-on, you are able to get that sensory input with that.” Paula concluded that the hands-on approaches associated with inquiry learning incorporated a sensory approach, which she felt supported understanding in students.

In the end, it became clear that these participants clearly identified that inquiry instruction provided a firm platform for learners’ sensory experience, which was beneficial for students with disabilities. While this might not be a theme commonly associated with the NRC’s (2000) image of inquiry, all the study participants considered inquiry to bring a multi-sensory approach to learning, which they found supported learning in students with disabilities.

**Benefits to teachers of science.** A number of participants indicated how inquiry instruction can be beneficial to teachers, indicating that inquiry instruction promoted planning and delivery of meaningful instruction, provided reinforcement of learning, scaffolded science instruction and allowed teachers to apply inquiry to teach other subjects

*Promoting planning of instruction.* Three participants (Brian, Debra, and Gail) believed that inquiry instruction allowed teachers to plan for meaningful science instruction for their students. In one instance, Brian, who stated earlier that inquiry works for all students, identified how inquiry instruction benefits teachers as well:

I think it makes sense to both kinds of students. It makes sense for both typical learners and atypical learners. It is just a good format—a good foundation to follow. And it gives the instructor a game plan too. (Brian, interview)
According to Brian, learning about inquiry instruction is beneficial to teachers in science since such instruction gives teachers a guideline for planning their inquiry instruction. Brian also mentioned during the interview that

I almost wish I could have taken this first. Then I could have used this for more of my lesson planning. I think this should be taught in more of our curriculum classes. I think it would be better to have this foundation initially.

Again, Brian conceptualized inquiry from the teacher’s perspective, which he believed gives teachers some support in their instructional planning.

Although not as prominent as Brian, Gail and Debra expressed similar sentiment. Gail felt that the five E’s of the Learning Cycle (Bybee, 2000) allowed teachers to develop science lessons in ways that supported student learning. Gail planned to use inquiry to teach any science lesson. “Being able to apply the five E’s when I am going to plan a science lesson, knowing how to go about that,” Gail said in the interview.

Debra held a similar position when she indicated that teachers “can use [inquiry] as generically across subjects.” Here, she felt that she could use inquiry either as a teacher in special education teaching science or as a science teacher. She mentioned, “If I get to become a science teacher, or work in a science room, I think it will be my to-go for.”

In sum, all participants felt that inquiry-based instruction gave a format to teachers that they could use to plan for instruction. Since participants, as teachers of science, developed inquiry lesson plans using the Learning Cycle (Bybee, 2000), they appeared to find planning for inquiry instruction using Learning Cycle components to be
beneficial to teachers. Their views are similar to that of NRC (2000) where the five essential features allow teachers to develop abilities of formulating scientific explanations from evidence.

**Increased scope for inquiry-based teaching.** A number of teachers also indicated that inquiry instruction can be applied to teaching subjects other than science. Brian considered inquiry-based teaching to be “transcendental in nature” and explained, “[Inquiry] can work with any student, any subject. I mean, it is not like it can be applied to only science and math. You can do this with every lesson.” Brian expressed that inquiry provided teachers with a format that teachers may use while teaching other subjects. Brian’s thoughts concurred with Debra’s, who also previously indicated that she could use inquiry as a science teacher if she worked in a science classroom.

Another prominent response about applying inquiry instruction to subjects other than science was provided by Jack, who not only held this view but also provided two examples of such applications. Jack explained, “Even in, like, Math—like you got to write it down [how you did it]—did this step, this step, this step, this step, and this step. Find your own way to do it.” Though Jack used the terminology that science educators could refer to as non-inquiry (inquiry as moving away from step-by-step procedure), Jack believed here that inquiry instruction allowed math students to move from one step to the next, each step building on the evidence of the previous step.

Again, for social studies, Jack explained that teachers can use inquiry instruction. He suggested, “For Social Studies, just give students a picture of something historical—say, like, a historical event. And then ask—so what do you think of this picture? The
time frame, how people dress, what was happening and so on.” While Jack’s responses do not exactly match the way inquiry learning is conceptualized by the NRC (2000), Jack believed that inquiry instruction can be applied to teaching other subjects, thereby demonstrating an increased scope for inquiry instruction.

**Providing reinforcement of learning.** Five participants (Kim, Emily, Brian, Jack, and Holly) considered inquiry instruction beneficial to teachers since inquiry instruction allowed teachers to provide their students with multiple opportunities for learning. For example, Kim, who considered hands-on activities and visuals as two most important components of inquiry-based learning, also indicated that this type of instruction worked with children with moderate to intense educational needs. She said, “I think a lot of times it is easier to connect when someone else is doing it first—like you see a video.” This belief is contrary to the way the NRC (2000) conceptualizes inquiry. If students watch a video before the exploration, they might receive an explanation before gathering their evidence, which would make it more like a confirmation lab. Kim felt however that providing students with multiple learning opportunities was a part of effective inquiry instruction. During the microteaching, Kim’s group provided multiple opportunities for learners to experience content while teaching a single topic. For instance, Kim’s group not only explained the science content of their activity using slides containing vocabulary terms and pictures but also used multiple analogies to explain science content related to their activity.

Another student, Emily, who partnered with Kim during the inquiry microteaching, also considered inquiry beneficial to teachers since inquiry allowed
teachers to reinforce concepts multiple times. Emily noted, “You want to pull it out to really good detail with it and inquiry just does that automatically” (Emily, interview). She further elaborated, “It’s like really making sure that they understand every detail and part of the lesson, so I think explaining it to them wide over and [do it] repeatedly.”

While Emily’s perception did not align with the Explanation feature as posited by the NRC (2000), she asserted that inquiry instruction allowed teachers to deliver multiple learning opportunities to students, and she felt that such explaining remained an important feature of inquiry.

Brian asserted a similar view, saying that inquiry instruction “is repetition” during his interview. While similar themes was not found in any other data sources collected from him, Brian did acknowledge that inquiry instruction provided teachers with multiple teaching opportunities.

A fourth participant, Holly, likewise indicated that inquiry instruction allowed for reinforcement of learning. While referring to her own microteaching where she used both a live cam video and a PowerPoint to engage her students, Holly indicated, “I chose both video and visuals. You know you want to reinforce the learning. And that’s how I do it, you know. Like if I’m the teacher.” In her teaching video, Holly used both slides and a live-cam to engage her students. Holly thus asserted that inquiry instruction permitted teachers to deliver instruction repeatedly.

One participant, Jack, indicated that preparing for teaching using inquiry made him relearn the science content himself. Jack explained, “In [the] research I did while I was planning for my [inquiry] microteaching, I think—wow! Some of the stuff I have
really forgotten,” (Jack, interview). Jack indicated that planning for inquiry instruction prompted him to learn science content as a teacher first in order to teach his students, and he was the only participant who expressed this view.

**Challenges to Inquiry Instruction in Special Education Context**

A number of participants indicated that inquiry learning could be difficult to execute, especially within the special education context. These participants not only identified how inquiry learning can be difficult for some students with disabilities but also indicated that inquiry instruction can be difficult to plan and execute for some teachers in special education.

**Difficult for some students with disabilities.** Participants identified a number of factors that could render inquiry learning to be difficult for certain students with disabilities. Factors such as low cognitive abilities, shorter attention spans, physical impairments, and behavioral issues emerged as potential challenges by some participants that may impede student’s learning by inquiry.

**Shorter attention spans.** Brian felt that inquiry learning can be difficult for learners with disabilities who tend to have shorter attention spans: “I think a lot of times our students have shorter attention spans, or limited cognitive skills.” He explained, “I think the biggest thing I look forward to is that once students are engaged, they really stay engaged.” Brian felt that students with shorter attention spans may lose interest quickly, making it essential to keep students engaged during inquiry.

But while Brian considered shorter attention spans to be a challenge to inquiry-based learning, other participants felt inquiry instruction may actually work for students
with shorter attention spans. For example, Francine considered inquiry instruction a useful way to address limitations due to attention spans in certain students with disabilities by keeping them engaged. She explained,

Especially with some kids like the kids with ADHD, it has to be very hands-on. Like keep them engaged. They actually don’t like watching something. If they are watching something, it has to happen quickly. But inquiry would give them something to do besides just staring at the teacher when they talk. (Francine, interview)

Here, Francine considered that inquiry instruction allowed learners with shorter attention spans to stay engaged with various components of inquiry.

Lower cognitive abilities. Some participants admitted that lower cognitive abilities in learners could prevent them from learning successfully by inquiry. One participant, Jack, commented on the inability of certain learners to understand inquiry:

“Some may not be able to grasp [the concept] because of the information, the content, as you are teaching them the content.” He further explained, “Like [students with moderate to intense needs] may not be capable of doing all these. With an IQ of 26, will they be able to communicate and justify effectively? You know—figure out what is happening?” (Jack, interview). He harbored the thought that communicating and justifying may be difficult with groups of special needs learners who he felt may have low levels of intellectual abilities. Jack continued, “That’s why you really need to explain and elaborate. You know, you got to do these things afterwards. That would be so much
better” (Jack, interview). Here, he identified that in order to make sense of experiences during inquiry learning, teachers needed to scaffold inquiry instruction.

Debra, conversely, had a different interpretation of students’ abilities when it came to comprehending inquiry instruction. She stated, “I think one of the biggest concerns with these students would be them not being able to get out of the lesson what you would want them to.” But she also added, “Maybe they are not getting to get out of them with all the guidance. Maybe because they work by it—the step-by-step learning. Teachers telling them exactly what to do.” Simply put, Debra believed that learners with disabilities may be more accustomed to direct instruction rather than doing and meaning-making of experiences on their own as inquiry learning requires. This prior experience with direct instruction became Debra’s reason as to why teachers needed to support students during inquiry learning. Debra’s explanation revealed why teacher guidance should be essential in some contexts of inquiry learning.

Another participant, Luke, indicated that students can draw their own (possibly incorrect) conclusions or could have difficulties with hands-on approaches. Luke explained:

Especially in special ed, I think maybe like, kind of like it has to do with having students draw their own conclusions sometimes and you might have to really help them along in drawing those connections. Offer more guidance than in a regular classroom. Well—the intense group—sometimes even following directions you know if you want to do a hands-on activity just difficult. I mean getting a whole
classroom to—I mean even though you have a pretty low student to teacher ratio but just even keeping it on track could probably be hard. (Luke, interview)

In this comment, Luke identified a number of challenges for teaching using inquiry to students with disabilities. Some students with disabilities might find it difficult to follow the instructions for certain activities and thus fail to accomplish learning by inquiry. Furthermore, with the diversity in needs and levels, it could become difficult for a teacher to maintain the same progress-level for all learners, which could be a barrier to successful inquiry learning.

**Behavioral issues.** Behavioral issues appeared as a challenge to at least three participants in the study. One example would be Adam, who mentioned that inquiry instruction would be difficult for children with Moderate to Intense Educational Needs. Adam explained, “To try to teach them something is very difficult. It’s like, you need to like, reinforce behaviors and all of that is kind of tied into it too” (Adam, interview).

On the contrary, Mike, a Moderate to Intense major, also showed concern with behavioral issues during inquiry with students with disabilities, but his interpretation of behavioral issues as a challenge was different from Adam’s. Referring back to his own microteaching experience, Mike explained, “I think that you have to be careful with that as well because with students in special education—they can obviously—like throw the things. Like throw the Ping-Pong ball” (Mike, interview). The purpose of addressing behavioral issues as a challenge stemmed from understanding the safety issues associated with hands-on activities in inquiry classrooms.
Another participant, Jack, who also indicated similar notions, stated, “You have to be careful who you are dealing with” during the interview, did not provide any further elaboration.

Opposite to Adam, Jack or Mike’s views, two participants (Holly and Francine) indicated that students with behavioral issues can be kept engaged with inquiry learning. Holly expressed during the interview that, “People with intellectual disabilities are a good with inquiry—and also ADHD.” She further explained her thoughts:

In ADHD, I think, it doesn’t work too well if you’re trying to tell Johnny to keep to his seat all the time. Johnny is going to get worse. Johnny needs that freedom to express how his mind works. And I guess it’s all about the modification again.

(Holly, interview)

Here, Judy felt inquiry could keep students with ADHD meaningfully engaged in learning rather than assuming a passive role. Francine asserted a similar perspective when she indicated:

Especially with some kids like the kids with ADHD, it has to be very hands-on. Like, keep them engaged. They actually don’t like watching something. If they are watching something, it has to happen quickly. But inquiry would give them something to do besides just staring at the teacher when they talk. (Francine, interview)

With this, Francine indicated that inquiry learning may allow students to remain engaged in learning during inquiry. From all these statements, participants identify how inquiry
learning can be difficult with some students with disabilities, but the same features can actually support learning in certain students.

**Learners’ disabilities as a challenge.** Another important barrier to successful practice of inquiry learning was learners’ own disability. For instance, Ida mentioned that special education teachers need to be mindful about learners’ conditions while teaching using inquiry, explaining:

> In the science classroom, noise can put concerns for some students. I know a lot autistic students, noise bothers them and I currently have students who get really set off by noise that might have trouble during that lab portion where everybody’s working and everything’s kind of—a lot of discussions and things like that going on. (Ida, interview)

In this case, Ida indicated that students with disabilities might not be able to participate fully in certain types of activities commonly associated with inquiry-learning, such as an active environment that can incorporate noise and movement, because certain learners with disabilities might not be able to function in that environment. Students with disabilities may prefer a quiet environment instead, and teachers need to tailor the amount of activity in their lessons according to these needs. This again paints a different picture of usefulness of a hands-on active environment when it comes to teaching students with disabilities. Ida’s views reveal that inquiry instruction clearly needed to be differentiated to make inquiry applicable to diverse learners.

**Difficult for some special education teachers.** While the above participants indicated how inquiry instruction can be difficult for certain learners with disabilities,
some participants indicated that inquiry instruction could be difficult for some teachers to plan and execute effectively. Challenges to teachers’ planning and delivery of effective inquiry instruction were diversity in learners’ needs and levels, and time and resources.

**Diversity in students’ needs a challenge.** The diversity of special education learners appeared to be another major emergent theme in this section, as many participants indicated that special education teachers could struggle with differentiating instruction due to the variety of students’ needs and levels. For example, Nancy stated that, “Sometimes it’s hard to know that all my students are on the same level.” She explained, “I don’t want to ask questions that only some would know. And the questions that [I ask]—I know that some of them might have no idea.” Here, Nancy felt that she did not intend to ask questions that only some of her students could answer. She believed the same way with hands-on approach that inquiry manifested, adding, “You know I don’t want to make that one student feel bad if he can hold things and do things and the other one can’t.” She believed that developing, effective instruction to accommodate all learners might be difficult with students with diverse needs and abilities.

Nancy also suggested that teachers needed to be mindful of the diverse students’ needs and abilities to make instruction effective in her classroom. Nancy explained:

I really like taking each student’s unique needs. Looking at them, guiding them throughout the lesson and making sure I know what questions to ask when to ask. Making sure that even that twenty minutes I have with them is meaningful.

(Nancy, interview)
With this, Nancy also asserted that knowledge of students’ needs has to be taken into account while planning for inquiry instruction for learners with diverse abilities.

Another participant, Brian, stated the following to explain his thoughts on using inquiry instruction with students with diverse needs and disabilities:

You have to take into consideration each learner. Like some of the kids that I have worked with need things to have been explained things in different ways. Some of them need instruction read to them up, and they understand it . . . Some may need a more visual approach. It just depends on your learner I guess. So I mean knowing your students and then modifying accordingly. (Brian, interview)

Here, Brian felt that diversity in needs and abilities in students could be an issue for special education teachers while planning for inquiry instruction. Because of their diverse abilities, teachers could struggle to differentiate instruction.

**Degree of openness as a challenge.** Another concern identified by the participants was the openness of the inquiry approach, which some participants considered a challenge. Many of the studied preservice teachers felt that being completely learner-centered might be difficult for students with disabilities. In one example, Brian previously indicated that students could have shorter attention spans or limited cognitive skills. As a result, she emphasized, “It is keeping them on track the part that is open to them—open to their exploration part of it [is difficult].” Brian felt the need for some structure to provide appropriate guidance to the students.

To Gail, “more structured” also meant providing specific instruction that students could easily follow and stay on track. She indicated, “If you don’t give them procedures,
especially when there is a lot going on like right now, you are going to get something really kind of crazy.” She elaborated:

I think with some of my students, the challenge may be keeping it structured to any degree. But if it is an open, or if it is tends to be a very open ended lesson, that it could be like you just can to take it any directions. You just have to be able to keep them focused on the content. With students in special education, it definitely is going to be hard. (Gail, interview)

Emily also felt that with inquiry, students with disabilities may “just miss what you would want them to learn” or “take advantage” of the situation if a balance in openness is not created:

You need to find a balance of how open you can be with your students because otherwise they can be like take advantage, or they may not understand what’s going on, or lose or like get off task. So I think it would be a weakness. But once you get to know your students, you will be able to navigate it better. (Emily, interview)

Here, Emily perceived that deciding on the amount of support from the teacher may be difficult in classrooms with students of a variety of needs and abilities. She also indicated that the teacher’s knowledge of the students was essential to decide on the amount of structured-guidance during inquiry-based learning. Thus, all these participants, in various capacities, indicated that some amount of structure was essential to support science learning with students with disabilities in an inquiry-based classroom.
Conversely, Francine interpreted the notion of “structure” completely differently from the above participants. She felt allowing a certain degree of openness could allow these learners to get involved with the topic and help them to learn it in a better way:

I think like a problem with them academically is that they, like, seem to lose interest easily and not engage—because they are always told exactly what to do. You are always like show them a movie, show them a power point. Instead—let them just play with it. I feel like they would learn a lot better in that way.

(Francine, interview)

Here, Francine meant structure to be step-by-step explicit direction that teachers require the students to follow. Francine considered this type of structured instruction was detrimental to student learning since it can limit student’s explorations during inquiry learning.

**Identifying learners as a challenge.** Olivia, an Early Childhood Intervention major, indicated that identifying the specific needs of the special education learner could be a challenge in itself that could pose a problem to the practice of inquiry. She stated:

I think the most important challenge is to identify the learner. That can reflect on what you expect them to know and learn. You know. Make sure they are mentally appropriate at their level, and that you’re not expecting more from them than they can give. (Olivia, interview)

Here, Olivia provided certain factors that could affect the differentiation of inquiry instruction. She believed that teachers must first identify the students’ needs in order to establish expectations from students.
Another participant, Francine, indicated that inquiry worked with students with disabilities noting, “People almost worry to teach special needs students because they can be so unpredictable.” Here, Francine also put forward a thought that it may be possible that teachers may find students with disabilities to be unpredictable and worry about teaching them.

Thus, all these participants identified certain factors that often make inquiry instruction difficult to plan and conduct with learners with disabilities. Be it the diversity in needs or certain conditions, participants abundantly identified several challenges to inquiry instruction when it came to applying inquiry in classrooms with students with disabilities.

**Adapting Inquiry Instruction for Diverse Learners**

During their interviews, 11 participants indicated that inquiry needed to be adapted for special education classrooms whereas five participants indicated that inquiry instruction could be adapted for diverse learners in the classroom.

Under this dichotomy, two key examples of participants who indicated that inquiry could be adapted for students with disabilities emerged. Kim, who indicated during the interview that inquiry worked with all students, both general science students and students with disabilities, responded, “I think the good thing about inquiry is that you can modify and adapt to each student” (Kim, interview). Kim held that inquiry instruction was adaptable, and thus, could be adapted to various settings.

Holly expressed a similar assertion by stating, “People with intellectual disabilities are a good with inquiry. I think [for] everybody . . . I guess it’s all about the
modification.” Like Kim, Holly provided that inquiry can be adapted to fit diverse learners in the classroom.

Alternatively, 11 participants indicated in their interviews that inquiry worked in various settings, but needed to be adapted for students with disabilities. One example was Carol, who suggested, “I think [inquiry] can work in any context as long as you modify it” (Carol, interview). Both participants who indicated that inquiry could be modified or needed to be modified provided several images of adaptation of inquiry instruction, which is described below.

**Adapting questions during inquiry.** At least five participants provided insights on how questions during inquiry can be modified to fit diverse learners in the classroom. Brian explained adapting inquiry in the following way:

The biggest [adaptation] I think is the questions that are asked with a purpose other than asking general questions. Like what do you think about the sun? Let’s say you are teaching about temperature and the sun, some from the special education perspective can be—is the sun hot or is it cold? Questions that get you to where you want to go. Questions as a vehicle from point A to point B—to reach your goals. (Brian, interview)

As interpreted by Brian, “purposeful questions” guide thinking in students with special needs, which Brian considered as one way to adapt inquiry instruction. Although this might not be directly related to modifying Question feature of inquiry as held by NRC (2000), such adaptation can guide learners with disabilities toward gathering and meaning-making of evidence. In a later part of the interview, Brian indicated, “There are
a lot of phrasing issues—be very specific with your questioning.” These adaptations can be applied to adapt the Questioning feature of inquiry (NRC, 2000), making inquiry appropriate for diverse learners in the classroom.

Nancy stated a similar notion as she felt that questions needed to be modified according to learners’ needs and levels in inquiry classrooms:

I think it is really important to ask questions first and foremost, especially for special needs students just because each learner is so unique. You know, if they have a certain disability, like all of my special needs learners—learners with disabilities will have different levels of knowledge. So I need to make sure I have the questions so know where each student is. (Nancy, interview)

She believed that diversity in needs and levels in learners with disabilities had to be carefully considered by science educators while framing questions during inquiry lessons. She elaborated, “I really like taking each student and looking at them, guiding them throughout the lesson and making sure I know what questions to ask when to ask” (Nancy, interview). Nancy remarked that she would ask questions, “but not too many to overwhelm them but enough so that it will guide them into their own.” This statement captures two themes in Nancy’s understanding about adaptation of inquiry instruction for learners with special needs: one, that questions in inquiry can guide learners with disabilities; and two, they need to be presented carefully such that they not overwhelm learners but still guides learners towards their own learning experiences.

While Brian indicated an adaptation of the wording of questions, and Nancy indicated adapting the number of questions, a third participant, Francine, also considered
adapting questioning from a different perspective. She believed that questions needed to be asked in a nurturing environment that would not intimidate students with disabilities. Francine shared her thoughts in the following way:

I think [for] some of them, if it is a hard question I would say, they might get discouraged if they don’t find the right answer. They need to be more of like—I feel like they know exactly what this is, but they need to be pushed to more directions. (Francine, interview)

Clearly for Francine, questions that are too difficult for students to answer can lead to a sense of discouragement. Instead, questions needed to be worded in ways to guide these learners without frustrating them. Francine further indicated that even if students do not get the answers, the environment should be supportive so that learners can still see where the questions are going. She commented, “I feel like even if they don’t give the right answer, they can still see how cool it is.” With her special needs students, she recommended using questions, too. She soon added, “They can be or say funny things, but then like say, that’s funny, but it’s still not right.” Here again, Francine indicated that questions needed to be asked carefully so that students are not made to feel uncomfortable when they do not achieve the desired results. Francine thus understood that looking for a single right answer is not in alignment with inquiry as inquiry learning incorporated evidence-based explanations.

Another participant, Mike, identified the need for adapting questions and believed that knowledge of learners’ needs and levels was important for understanding what questions would be appropriate for them. He expressed:
I mean as a teacher you are going to pay attention to what’s going on and make sure that you that you know your students and know like what questions are going to overwhelm them. And how to ask questions. Because some students need a two choice question. Or instead of an open-ended question umm. Other students do fine with that type of question. It just all depends on the students. (Mike, interview)

With this, Mike indicated that not all questions in a lab would be uniform and might need to be modified according to the learners’ needs and levels. Furthermore, this knowledge would help teachers identify how the questions should be delivered or what modes of answers are appropriate for the group.

One participant, Carol, indicated that adaptation of questioning might include helping students to come up with their own questions. In her interview, Carol provided descriptions of how she felt questions from learners could be modified. She suggested giving students “some ideas for questions, maybe the prompts so that they can come up with their own questions.” Carol also provided some specific suggestions for how she would help her students with the development of inquiry questions. Carol explained, “Like when I see that they can’t generate their own questions, suggest some. Guide them in the right direction. I don’t like when people give students the answers. But yeah—guide them in the right direction.” Thus, according to Carol, adaptation of questioning included providing guidance to students such that they come up with their own inquiry questions. This perspective did not materialize in any other participants’ views on adaptation of questioning.
Each of the participants indicated that questions could be modified to accommodate diverse learners’ needs. Many participants, nevertheless, described questioning in terms of what questions teachers ask during inquiry-based science instruction rather than allowing students to develop their own questions toward data collection and interpretation of evidence as interpreted by the NRC (2000). Only one student indicated that adaptation of questioning could guide learners so that they can initiate developing their own questions.

**Adapting hands-on experiences during inquiry.** A number of participants conveyed that activities and hands-on experiences needed to be modified to best accommodate all learners in an inquiry-based classroom. All of the responses about adaptation also came from participants who felt hands-on experience supported learners with special needs. For example, Mike earlier indicated that teachers ought to be careful with inquiry activities because students in special education might not understand the safety issues involved. Mike pointed out an important aspect about modifying inquiry activities in the special education context that special education teachers need to understand safety procedures associated with the activity and make sure students understand the same. Explaining safety procedures can be difficult for some groups of special needs learners, hence the need for clearly articulating such procedures may be important.

Ida noted that some students with disabilities might not want to touch materials during a hands-on inquiry-based exploration. She explained that, “The hands-on
activities would be good for most but some might not want to touch some of the materials.” She called for other strategies to remain available for such learners:

So the visuals would be good for them to make more connections and to draw pictures if they’re really I would say moderate to severe. They might just sit and draw a picture of a bird or draw a picture of the nest instead of building or the interactive games. (Ida, interview)

Ida further explained that, “Some students may not want to participate in the group and may be having a really hard time socially but they can get on the computer and interact with a game.” Here she provided some strategies for adaptation:

Maybe take a break—Not that they shouldn’t participate in a group because they need that socialization but they would take a break and play on the-the computer at the same time keeping with the lesson. (Ida, interview)

Nancy, another undergraduate Mild to Moderate Educational Needs major, held the notion that hands-on activities might not work for certain learners with certain kinds of impairments, for example, physical or visual impairments. She explained, “Because it’s hard with hands-on, too, just because if they have physical impairments. It’s just hard.” She also reflected on her experience of teaching hands-on activities to students with visual impairments, recalling that, “one of the students I did work with, he had visual impairments so he wasn’t able to do the hands-on things.”

These participants expressed that hands-on experiences occurring during inquiry needed to be adapted in order for learners to more fully take part in the activities. Specific examples as stated above indicate that hands-on experience could hold a
different connotation when done with learners with disabilities (e.g., some students may need a quieter environment to learn, some students work better individually, some students need frequent breaks, etc.). Teachers of students with special needs must keep these insights in mind in order to develop appropriate hands-on experiences for their students.

**Constructs Referred to While Expressing Views of Inquiry**

The study participants referred to certain factors when they came to express their views about inquiry learning and teaching. Some prominent factors included previous science learning experience, preference to inquiry as learners of science and previous experience in special education, some of which are discussed below.

**I never learned science by inquiry as a student: Reference to previous science learning experiences.** The participating preservice special education teachers often referred to their own science learning experiences while expressing their views on scientific inquiry. When expressing the view that inquiry benefited all students, not just students with disabilities, seven participants (Kim, Francine, Carol, Luke, Jack, Gail, and Olivia) drew from their previous learning experience. Each indicated that inquiry learning differed from the lecture method of science instruction, which they experienced as learners of science. Gail indicated that “[inquiry] was engaging. It was definitely different than my own science experience in high school.” Emily recalled, “I really struggled with science in my grade school. And I feel like if my teacher or my classroom was bit more inquiry-based, I think it would have helped me a lot to learn more.” In her pre-questionnaire, Emily wrote, “I have always struggled with science, but loved
experiments” (Emily, pre-questionnaire). Another participant, Luke, reflected back to his own science experience:

Just thinking back to when I was in school . . . I know some teachers had that kind of a format like an inquiry type format. I just enjoyed it a lot more, I feel like I got a lot more out of it. And learned a lot more efficiently. (Luke, interview)

Luke indicated that he enjoyed learning by inquiry when he was in school. He not only found learning by inquiry to incorporate a sense of enjoyment, but also felt he learned better with inquiry instruction.

I learn better this way: Preference to learning by inquiry. A second construct to which the participants referred while expressing their views on inquiry was their own learning style. These participants all indicated that they preferred learning by inquiry as learners of science. A notable example is Kim, who considered herself “not the biggest fan of lecture” and held that “all subject areas could be inquiry-based.” Kim also indicated during the interview, “I know that I don’t learn best through lectures. I know I learn best with hands-on experiences. So I think it would be great for everyone.” In this excerpt, Kim’s preference of inquiry as a learner of science and the way she thinks that inquiry works with all students are evidently connected. She recognized how inquiry differed from lecture, which resonated with her own learning style and led her to believe that inquiry would be beneficial to other students for the same reason.

Another example emerged with Francine, who held a similar view. Francine considered herself a “hands-on learner” who did not learn best when told information or asked to read it. Francine articulated:
I feel like any student needs to know this instead of a lecture. It just works for all students. I mean if you are talking at me, I am not just going to learn it. But if I am going to learn if I find out why it happened that way, or make that happen and observe and understand. I am like more of a hands-on learner. I just can’t be like told things. And also with the my friends—they are like—oh didn’t you read the texts and I am like no I didn’t, but I feel like I don’t like having read to!

(Francine, interview)

At another point in the interview, Francine added:

I hate the teachers who just want you to absorb all this knowledge and expect students to regurgitate that like verbatim. I feel like they need to learn the other way. I feel like I learn a lot better when I find things out for myself and then find out why that’s the answer. I think that’s important for anyone. (Francine, interview)

Francine perhaps believed that inquiry worked for any student since inquiry resonated with her own learning style—which was learning by hands-on experience.

Another participant, Mike, asserted that inquiry-based teaching supported learning for all learners, including students in special education. Mike referred to his own learning experience, telling me how he benefited as a student with hands-on approach:

I know for myself in high school and middle school and all throughout grade school, I taught myself a lot of math. I was pretty good at math but I sat down and figured out my own ways of doing it, doing different problems. So I consider that [as inquiry] where I used my—my own knowledge, own background
knowledge. So I think that’s a big part of learning in itself. And also, you should also have the teacher who explains things to you, too. That also helps to develop students’ sense of understanding and making meaning on their own. (Mike, interview)

Although Mike’s notion about inquiry might differ from the view of inquiry established by the NRC (Mike referred to teachers explaining, rather than students finding the answers for themselves), he still draws from his own learning experience, where he, as a learner, builds on his background knowledge, which he considers as inquiry.

Debra, another Mild to Moderate special education major, indicated,

When I learn something and it sticks with me. When it finally hit me—and then I learned it. So I think it that to figure things out, having the things [to be] found out for themselves, discover them [sic]. I think [in that way] they stick better with you.

She also mentioned that all her labs as a student were “cookbook labs,” and she did not have much inquiry exposure when she was a student.

Thus, all these students indicated that inquiry-based learning differed from lecture-based methods of learning science, which did work for them when they were students of science. Further, they preferred learning by inquiry and believed that they as students would have benefitted from being allowed to understand concepts by firsthand experience.

From my experience in special education: Reference to previous experiences in special education. Some participants also referred to their previous learning
experiences with students with disabilities while developing certain views. An example would be Brian, who believed that inquiry instruction needed to be modified according to the students’ needs—a view that emerged from his reflection on field experience when he worked with students with disabilities:

I found that from my field experience is that you have to take into consideration each learner. Like some of the kids that I have worked with need things to have been explained things in different ways. Some of them need instructions read to them and they understand it. It’s a problem with say their receptive and expressive language skills. Other things that I have found that may need a more visual approach. It just depends on your learner I guess. So I mean knowing your students and then modifying accordingly. (Brian, interview)

Brian probably has experienced that students with disabilities struggle with mastering the diverse skills needed to understand certain concepts and express their understanding. As an instructor he had probably evidenced one student to benefit from one particular form of instruction. He then identified the need of inquiry instruction to be adapted.

Another student who expressed a similar position was Olivia. She considered inquiry learning as a good way to engage students with disabilities, but her views also grew from her past experience of working in a special education classroom as a special education teacher’s aide. The following excerpt from her interview underlines how she developed her thinking:

And I am thinking as my working as an aide with these students and I wish I knew this then because I could have done a lot of experiments with them.
Because, the classroom teacher in special education—I mean when a special education student continues his education and advances from let’s say from early childhood to fourth grade, then fifth grade, sixth grade, the gap in the knowledge gets wider and wider. It’s hard for these kids to grasp what is being taught.

(Olivia, interview)

The above participants drew from their previous experiences working with students with disabilities and thus explained how their backgrounds affected the way they thought about inquiry.

**The science methods course as the first experience with inquiry.** The participants indicated that they had minimal or no experience of learning about scientific inquiry prior to this class. Ten participants indicated that they had absolutely no prior experience with the term “inquiry.” In a prominent way, Carol indicated that she had “heard of scientific method but not scientific inquiry,” and the only thing she remembered as a student. When I asked them where they first learned about inquiry, “here, in this class” was the most common response.

But some participants indicated other methods courses and courses in special education where participants took part in some inquiry-based learning. For example, Carol recalled, “I took Teaching History in middle grades. [Our teacher] had us do a lot of hands-on things, like group work. I think that would be the closest thing to the one I had here.” Brian, like Carol, had some prior experience in inquiry-based learning from his math methods course. Brian articulated that experience:
It was probably last semester in my math curriculum class. That was, I believe, our first or second class of teaching math using inquiry. And it was more like—okay here is how we are going to go about this course. But it wasn’t seen as explicitly in every class. (Brian, interview)

Brian soon added:

As far as math goes, yeah maybe [we did inquiry]. But we didn’t *teach* using inquiry—we did like group activities, where we would work as groups. Like solving a problem or coming up with a math solution, but we didn’t really do any teaching, like microteaching. (Brian, interview)

Here, Brian clarified that in that course, they solved math problems by inquiry but did not get an opportunity to learn about inquiry or learn about teaching using inquiry.

Francine indicated that the special education course Introduction to Exceptionalities allowed her to do something that she felt was similar to inquiry. She summed up her thinking as such:

Sometimes we do, like, case studies in Introduction to Exceptionalities. You would like give you a little bio of a student. They are having an issue with x, y and z and they behave in this way and we kind of have to take that and try and diagnose them. (Francine, interview)

Here, Francine indicated that she may have had experience participating in inquiry learning but did not learn about inquiry. This group of participants clearly had minimal experience of inquiry as learners and practically no experience of inquiry as teachers.
Summary of Results for Research Question 3

This part of the data analysis investigated the views of scientific inquiry as held by preservice special education teachers. Qualitative analysis of data indicates that the participants in general considered inquiry to work with all students, including students with disabilities. But elaboration of their views indicated that participants identified certain benefits and challenges to inquiry learning. While several participants indicated inquiry learning could support students in a variety of ways, some indicated that inquiry learning could be difficult with some students with disabilities. From the teachers’ perspective, a similar dichotomy appeared with their views. While a higher number of participants recognized benefits of inquiry instruction to teachers of science, some expressed that inquiry instruction could be difficult to plan and deliver in the special education context. Further, the benefits identified by participants sometimes matched a conceptual image of inquiry (inquiry promoting understanding and enjoyment in science), although sometimes it became inconsistent with the NRC’s (2000) views (such as inquiry providing sensory experiences or inquiry providing reinforcement of learning) bringing new usefulness to learning by inquiry (NRC, 2000). Participants’ views, however, also reveal conflicting images of the NRC and are discussed in the next chapter.

Many participants articulated that inquiry instruction could be adapted to accommodate diverse learners in the classroom, but this pool of participants did provide modification strategies of questions and hands-on activities only. I also found their views to be influenced by the participants’ previous science learning experiences and experiences with students with disabilities. Several participants indicated that their own
previous science learning experience was *not* inquiry-based, though they preferred inquiry learning. Several indicated that this course was their first formal experience of learning about inquiry and learning to teach using inquiry. The implications for these views appear in the next chapter.

**Findings to Research Question 4: Future Plans for Inquiry**

The final part of my research explored the participants’ future plans with scientific inquiry. All participants *were willing to* incorporate inquiry instruction in their future science teaching. But their reasons and future plans indicated diverse interpretations of inquiry. Participants’ reasons for including inquiry and their future plans also matched the way they conceptualized inquiry. The participants envisioned teaching using inquiry in *different instructional settings* and identified certain *concerns* about their future practice of inquiry instruction. The results of Research Question 4 are outlined in Figure 4 (with theoretical codes italicized) and described in the following narrative.

Each of the 16 participants responded that they would be willing to incorporate inquiry instruction in future science teaching situations. Among this willingness, some variation appeared. Some of the participants shared a stronger inclination toward using inquiry instruction in the future than others. For example, “I am *definitely* going do it” (Brian), “Yes, *definitely*” (Kim), “*Oh yes, I will*” (Emily), “*I will. There’s no doubt*” (Holly), “*Oh definitely, definitely*” (Mike), “*Yes, absolutely*” (Nancy), “*Oh yes, I will*” (Paula), “Oh, yeah—I would” (Ida) and “*Yes*” (Jack). In some of these responses, I italicized the words that reflected participants’ stronger tone in the audio recording.


Figure 8. Theoretical codes and emergent codes for Research Question 4: Preservice special education teachers’ future plans with inquiry (with theoretical codes italicized).

**Intent: All Willing to Incorporate Inquiry**

At the other end of the spectrum, other participants, who also willingly incorporated inquiry into their future classrooms, did not express a strong inclination as the earlier group. For instance, “I think so” (Francine), “I will be trying and use it as much as possible” (Carol), “It depends on where you will be—but I will” (Jack), “In an ideal world, it will be mostly inquiry” (Gail), “I would try to do inquiry” (Olivia), “I’d probably use” (Adam), and “I guess I would” (Debra). Even if the second group of participants shared a lesser degree of readiness to use inquiry instruction in future classrooms, they were all to provide me with a detailed account of how they envisioned using inquiry as teachers. The diversity in their willingness prompted me to investigate a wide range of reasons for their inclusion decision and future plans of teaching using

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inquiry. This wide range indicated participants’ diverse interpretations of inquiry—some closely matching inquiry as conceptualized by the NRC (2000), some less so.

**Various Reasons for Including Inquiry in Future Teaching**

Two participants, Francine and Gail, chose to incorporate inquiry into their future classrooms since they believed inquiry allowed students to learn by engaging in hands-on experiences and reflecting on those hands-on experiences, activities they considered beneficial to students. The first example is Francine, who indicated, “I think being able to look for evidence and explaining things to them will be an important part of my teaching.” She further explained:

> Like if I am doing a unit, like the first part of the unit would be like let’s get all the information out. So the beginning would be like where you lay it all and the next part would be reinforcing through inquiry.  

(Francine, interview)

Here, Francine recognized evidence interpretation to be an important aspect of inquiry instruction and wanted to incorporate this in her future classroom; however, her future vision does not provide insights on students learning by interpreting evidence themselves. Rather, she envisioned teachers providing some background information to learners and then guiding the meaning-making of activities using inquiry. This was a partial match with the NRC (2000). Furthermore, this lined up with the way she had conceptualized inquiry in earlier statements. She had previously considered inquiry to be learning by interpreting evidence and considered it to be beneficial to students. Now she planned to carry her conceptualizations to her future science teaching.
Like Francine, Gail considered inquiry to be learning by interpreting evidence and considered it to be beneficial to students. In this section, the same interpretation of inquiry established her choice to use inquiry with her future students. She described her future inquiry classroom in the following way:

I feel like it has to be almost like question based. Like, you kind of, you know. Not expect terms and definitions but student must be able to ask questions and teachers must be able to supporting their answers. Feel confident in trying to defend their answers—like trying to defend their answer. That would be the environment probably. (Gail, interview)

Gail envisioned guiding students to justify their answers with reasoning rather than memorizing terms and concepts. Gail’s vision thus included students learning by justifying results with evidence, which to some extent matched the theoretical image of inquiry (NRC, 2000). Gail still indicated that teachers supported students’ justification of answers, an idea somewhat different from the NRC’s Communicating and Justifying feature of inquiry (NRC, 2000), and just as in the NRC, learners themselves support their answers with reasoning. Gail believed that teachers needed to proceed with the justification of results in terms of evidence to support meaning-making in students. This idea often appears in her earlier definitions of inquiry.

Many of the other participants chose to incorporate inquiry in their future classrooms, but they considered inquiry to primarily be hands-on learning. These participants did not include the role of evidence in their future plans. Participants with these views believed that inquiry provides a hands-on learning environment in which
students assumed an active role as opposed to sitting and listening to lectures. One example is Kim, who indicated that she would use inquiry in the following way: “Some hands on learning, some experiments involved.” She further explained her future inquiry classroom by stating, “I would definitely be starting off with questions and letting students think and let them explore a little bit on their own rather than giving them the answers.” She continued, “For this, I would use the hands-on activities. And just connect more to the topic.” Here, Kim placed importance on students taking part in their own learning by engaging in hands-on experiences but also indicated how she, as a teacher, would support students’ meaning-making of such experiences. Kim’s vision aligned with the way she characterized and viewed inquiry. Kim previously interpreted inquiry as a hands-on, teacher-guided process of learning, which she found beneficial to her students and now planned to take her views to frame her future teaching.

Another participant, whose future plans matched the way she interpreted inquiry, was Paula. She explained her plans in the following way:

I take a very sensory approach to the classroom. And although it’s not science per se, with one person I am thinking—take medium from outside—like soil, dirt or leaves and bring onto class and let the kids explore it. Touch it and feel it and getting a whole sensory input . . . It’s a part of the experience. (Paula, interview)

Here again, Paula indicated that in her future classroom, students would be able to experience concepts, which can be considered with a match with NRC’s insights. Paula’s future vision also corresponded to her conceptualization of inquiry, since she had previously indicated that inquiry brought sensory elements to learning.
In her post-questionnaire, another participant Emily wrote, “I need to be able to teach all subjects, so this course was needed” (Emily, Post-questionnaire). She also indicated a willingness to incorporate inquiry, stating during the interview that she would use inquiry “In all the ways that we learned in this class—using the features, the levels of it, the tasks and all that.” When asked to elaborate her views further, she explained:

I would like to do like all of them. Specifically the hands on—specifically like little experiment things where they can be free to experiment. All kind of different ways like demonstrations because I want my students to know what I expect. Videos because I think that’s a great way to unwind these kids—so educational. Visuals would be like I said everywhere and anywhere in my classroom. And interactive games—maybe I would use with students who finish quicker so that they are always busy doing something educational. (Emily, interview)

Emily’s vision of inquiry instruction indicated the use of various teaching strategies that could be used during inquiry instruction, although her use of the strategies did not reveal any understanding of learning by interpreting evidence. Instead, her visions included using these strategies as multiple ways to teach science to learners, which she considered inquiry-based teaching. As described previously, Emily conceptualized inquiry as a way to reinforce learning and loved inquiry since it allowed in-depth instruction. Even though she wanted to use inquiry in the future, her reasons and future plans did not match the way inquiry was encouraged by the NRC (2000).
The same conclusion could be drawn for Brian, who viewed inquiry as a technique to guide students’ thoughts, rather than considering inquiry to be learning by interpreting evidence. Brian explained, “I am going to plan about how I get students’ attention, how I show—you know, moving beyond step to step.” He quickly added:

I think a lot of times you do an activity to start—it kind of draws them in, get their minds going in what direction you need them to go. . . . So I would say that any time you are teaching, I think you should be having one of these in mind, which, even if it is at the back of your mind, which one am I working on right now? And what is the purpose? These all have a purpose—that’s how I see it. (Brian, interview)

Yet again, Brian believed inquiry to guide the direction of students’ thoughts, which was the same way that he characterized inquiry. Still, Brian indicated some difficulties in practicing inquiry in this way. He expressed earlier:

It’s hard for me to bridge the extending to justifying and communicating perhaps. It’s hard to bridge that—like from going. Like a lot of time extension take—they kind of go towards different veins of thought. And then you have to get back to your original vein of thought with the justifying. So that’s the only [challenge].

(Brian, interview)

This fundamental example of Brian’s interpretation of inquiry actually created some problems in the ways he wanted to practice inquiry. In addition, both in the interview and in his reflection paper, Brian considered this format of teaching somewhat limiting
for the teachers. Brian reflected on his previous experience with teaching students with disabilities in a resource room where he helped his cooperating teacher with reading:

She draws them thorough questions. Like all her lessons she asked questions to guide them. She does not follow a specific format. Any time, I have done a lesson, I have tried to follow this format and it’s worthwhile. (Brian, interview)

In sum, Brian considered inquiry to be a guiding technique using questions and intended to use inquiry in the future according to that conceptualization.

Thus, the participants excitedly included inquiry instruction in their future science teaching for various reasons, some matching the way inquiry is encouraged by the NRC (2000) but others not. Several of their future plans matched the ways participants characterized and viewed inquiry. The implications for such plans are discussed in the next chapter.

**Envisioning Inquiry Instruction in Diverse Future Instructional Settings**

Another interesting result that developed from the qualitative analysis of the interview transcripts was the significant diversity in instructional settings that participants envisioned themselves teaching in using inquiry instruction in the future. Table 6 illustrates a summary of various instructional settings in which participants envisioned teaching inquiry. The variety in future instructional settings as suggests the possibility of inquiry instruction could be conducted by special education teachers in a variety of instructional settings.
Table 6

*Future Science Instructional Settings Envisioned by Preservice Special Education Teachers*

<table>
<thead>
<tr>
<th>Role and Instructional Setting</th>
<th>Participant</th>
<th>Academic Standing, special education concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting students with disabilities in inclusive classroom</td>
<td>Adam</td>
<td>B.Ed. (Junior), MM-LAR</td>
</tr>
<tr>
<td></td>
<td>Debra</td>
<td>B.Ed. (Junior), MM</td>
</tr>
<tr>
<td></td>
<td>Gail</td>
<td>B.Ed. (Senior), MM</td>
</tr>
<tr>
<td></td>
<td>Holly</td>
<td>M. Ed. (Graduate), MM</td>
</tr>
<tr>
<td></td>
<td>Luke</td>
<td>B.Ed. (Junior), MI</td>
</tr>
<tr>
<td></td>
<td>Mike</td>
<td>B.Ed. (Senior), MI</td>
</tr>
<tr>
<td>Co-teaching in inclusive classroom</td>
<td>Carol</td>
<td>B.Ed. (Junior), MM</td>
</tr>
<tr>
<td></td>
<td>Francine</td>
<td>B.Ed. (Senior), MM</td>
</tr>
<tr>
<td></td>
<td>Ida</td>
<td>M. Ed. (Graduate), MM</td>
</tr>
<tr>
<td></td>
<td>Jack</td>
<td>M. Ed. (Graduate), MM</td>
</tr>
<tr>
<td></td>
<td>Olivia</td>
<td>M. Ed. (Graduate), ECI</td>
</tr>
<tr>
<td>Teaching in a resource room</td>
<td>Kim</td>
<td>B.Ed. (Junior), MI</td>
</tr>
<tr>
<td></td>
<td>Nancy</td>
<td>B.Ed. (Senior), MI</td>
</tr>
<tr>
<td>Mix of both—Supporting students with disabilities in inclusive classroom and pull out groups</td>
<td>Emily</td>
<td>B.Ed. (Senior), MM</td>
</tr>
<tr>
<td></td>
<td>Paula</td>
<td>M. Ed. (Graduate), ECI</td>
</tr>
</tbody>
</table>


Two participants, Kim and Luke, both Moderate to Intense majors, believed that their degree could call for the type of instructional setting that they envisioned. For
example, Kim asserted that with her major, she would obviously be placed in a resource room setting. While elaborating her future plans, she indicated:

I am a Moderate to Intensive [major]. So it would probably be a resource room or a purely special education classroom. Not inclusion. I mean not that I won’t teach it, but with my degree—I think that would be a resource room most of the time.

(Kim, interview)

In this statement, Kim believed that with her specialization, she would likely teach in a resource room, but she recognized the possibility of teaching in other situations and would willingly do so. Along similar lines, Luke indicated in his questionnaire, “I think [this course] will be very important. I will likely be teaching all subjects in my classroom” (Luke, Post-Questionnaire). Few other participants felt that they needed to be a well-rounded teacher, but did not include teaching in specific settings.

**Concerns Expressed With Future Practice of Inquiry Instruction**

In their articulation of their future use of inquiry instruction, participants identified some potential concerns about the effective use of the practice of inquiry. Major issues identified as barriers to effective inquiry instruction in future settings included diversity in learners’ needs and abilities, lack of science content knowledge, lack of time and resources, and lack of opportunity to teach science in the future. Some of these concerns about future use of inquiry were similar to the concerns expressed in Question 3’s exploration of participants’ views of inquiry. For example, participants have previously reported the need of time and resources to affect inquiry-based teaching.
Fear of lack of science content knowledge. All of the 16 participants indicated lack of content knowledge to be a concern in their future practice of inquiry instruction in at least one data source. Luke did not express this concern during the interview but identified the same issue in his post-questionnaire: “I see content as my biggest challenge in the future” (Luke, Post-questionnaire). Ten participants indicated the fear of lack of content knowledge in two data sources, the post-questionnaire and the interview. Here are some examples that represent their thinking.

Emily expressed a concern about her practice of inquiry instruction in her future classroom by stating, “It’s the content that scares me the most.” She further indicated, “Once I know the content backwards forwards, I will be able to teach [inquiry] with confidence.” The same concern also appeared in her post-questionnaire when she wrote, “Teaching science scares me because it is my weakest subject” (Emily, Post-questionnaire). In another place she wrote, “Students asking questions about science, gives me anxiety” (Emily, Post-questionnaire). These views indicated a possibility that Emily might not be able to teach science using inquiry not just because of her own lack of content knowledge, but because such fear may prevent her from allowing her students to ask questions, which is an integral part of inquiry (NRC, 2000).

Another participant, Debra, expressed similar concerns. She mentioned during the interview that she felt fairly confident with her future science teaching, but added, “Only if I am not putting in content” (Debra, interview). Fear of lack of content knowledge was found in her post-questionnaire where she wrote, “If I have to teach anything past freshman year science, I would see that as a big challenge” (Debra, Post-
questionnaire). Several of the participants identified that content knowledge was essential to practice inquiry and sensed their own lack of science content knowledge.

Moreover, some of the participants took co-teaching as a refuge to address their lack of science content knowledge. These participants believed that in co-teaching situations, the science teacher would be responsible for teaching the science content, and they would be present to provide support to students who may need it. Here are some examples of such thoughts found in the participants:

Carol remarked, “I always want to understand it first if I want to teach it to my students. I feel like this has always been one of my main worries, especially being a special education teacher.” When I asked her in what instructional settings she preferred to teach science in the future, she responded:

I think co-teaching. Like I said, I was in a resource room and I liked it, I had a good relationship with some of the students I was with. But it was frustrating at times because I saw the teachers having to do the same things that I did. Like they would ask me a question and I had to find a textbook and teach it to myself before I taught it to them and I didn’t feel confident. There is like a forensic unit in science class—and I never took that. So it was like how am I supposed to help someone? We have all kinds of grades and subjects going on there. So I really didn’t feel comfortable in the resource room. (Carol, interview)

In this excerpt, Carol identified how she, as a teacher, struggled with science content when she taught alone in a resource room. To gain respite from teaching content alone, she preferred to teach science in co-taught classrooms.
Ida also preferred co-teaching for the same reason. She stated, “I would say co-teaching an inclusive setting because I think that I would feel comfort in knowing that I have the teacher to help me with the content. That would make me feel more comfortable.” Thus Ida interpreted co-teaching as a situation where the science teacher delivered content and the special education teacher provided support. Participants did not recognize that co-teaching might require sharing of all teaching responsibilities, including the teaching of content.

**Lack of time and resources.** A few study participants recognized that time and resource limitations would affect the successful practice of inquiry instruction. Francine stated during her interview, “You know, we don’t know if every time if we can afford these five or ten sets of every [materials for the] experiment that I try to do but if that’s possible, that would be awesome.” Here, Francine believed that inquiry instruction needed more resources for developing hands-on activities for engaging students during inquiry.

Adam also specified “time and resources” as a factor affecting his willingness to use inquiry instruction, particularly for students in special education. “They need computers or the different machines to help them learn,” Adam remarked during the interview. He probably indicated the different types of assistive technologies that support teaching students with disabilities in general and not just for inquiry. Nonetheless, only these two participants considered resource limitation to be a factor in their future science teaching situations.
Ida and Brian provided that inquiry instruction needed more time for planning and execution and that teachers needed to take into consideration these factors while preparing to teach science using inquiry instruction. For her future inquiry instruction, Ida confirmed, “I would use visuals. It is time consuming to do them but they are [good].” She wanted to use visuals in her future inquiry classrooms and stated, “I think some teachers who don’t have a lot of visuals it’s because it’s time consuming. You need to print them out, find them and get them ready.” Brian articulated a similar thought when he noted that inquiry instruction “might take a little longer planning . . . might need more thought.” These participants believed that teachers taking time to plan for inquiry could be key factor that affected their future inquiry teaching situations.

**Lack of future science teaching opportunities.** Some participants remained unsure about whether they would get an opportunity to teach science in their future settings. For example, Francine revealed, “I don’t know if I will actually get to, like, teach a subject, because right now what I feel is that I would be more likely to be teaching reading and math because it is those are the ones that are now really focused on.”

Paula, the Early Childhood Intervention major, also lamented a likely lack of science teaching in her future teaching opportunities. Paula mentioned that the early grades are not given enough opportunity to do science in schools (“there is just math and reading”) and therefore early childhood students have less experience with inquiry. She indicated that too much emphasis on math and reading in the early years of education could be an obstacle to the practice of inquiry with her students. When asked to mention
a concern that she had about inquiry, she stated, “The government getting in the way.”

She detailed her thoughts by explaining,

I mean it’s more just outside. It’s like the common core, the curriculum and the way it is run today. Like everything is very math and reading entirely. And this is really kind of sad because it is building a lifetime in my children not liking school.

For Brian, the physical environment in the early grades classroom was often not conducive to performing or conducting inquiry. He noted, “In elementary schools I have been at, the rooms, the classroom environment is not geared towards science so much. It’s much more like students sitting in their little desks, and work on their seat.”

According to Brian, such classroom settings did not support active involvement in students that an inquiry-based lab may need. He confirmed, “In the high school that may be different—where there may be lot more labs, but as far as elementary schools are concerned, classroom environment is [a concern].”

Holly, another Mild to Moderate special education major, also expressed that she would love to use inquiry, but clarified that she could not because she would probably not get an opportunity to teach science “because I’m not highly qualified in science,” as she mentioned in her interview. Interestingly, she emerged as one of the few participants who held an informed understanding about inquiry along with a positive view and willingness to teach science by inquiry. These participants firmly identified the fact that lack of science teaching possibilities could affect their future inquiry instruction.
Summary of Results of Research Question 4: Future Plans for Inquiry

In general, participants were willing to use inquiry in their future science classrooms but chose to do so perceiving diverse benefits of inquiry learning, only some matching with theoretical insights provided by the NRC (2000). Also, they saw themselves using inquiry in a variety of settings in the future. Participants expressed some concerns about their future inquiry instruction. The primary concern came to be a lack of science content knowledge, and other factors included lack of time and resources and lack of science teaching opportunities in their future classrooms, some concerns also found in their earlier views of inquiry.

A Synopsis of Overall Findings of the Study

This chapter revealed how 16 preservice special education teachers defined and characterized scientific inquiry, enacted their inquiry instruction in the context of a science methods course, viewed teaching using inquiry, and held future plans for inquiry instructions. I compared emergent themes against the NRC’s (2000) version of inquiry to identify matches and mismatches against this theoretical insight. The key findings are summarized below.

Regarding the first research question, the participants seldom conceptualized inquiry from the learners’ perspective, as described by the NRC (2000). They often conceptualized inquiry from the teacher’s perspective, considering inquiry to be a process of guiding students. In terms of the five features, participants’ conceptualizations mostly included the first three features of inquiry (NRC, 2000): asking questions, looking at evidence, and explaining results to students. But here again, several mismatches
surfaced when compared to the NRC’s conceptualization of inquiry. While some participants indicated that *teachers* asked questions to initiate inquiry investigations (a match with teacher-directed inquiry as envisioned by the NRC), participants in other instances indicated that teachers used questioning for other purposes (e.g., scaffolding instruction, promoting critical thinking, etc.) as opposed to prompting data collection and analysis *and still* considered that as a part of inquiry learning. The concept of *students* interpreting evidence seldom occurred as participants considered it the teacher’s duty to interpret evidence for their students during inquiry. Additionally, the participants merged the *Explaining, Extending, and Communicating and Justifying* features of inquiry while explaining the role of science instructors in debriefing inquiry activities.

For the second research question, the study participants exhibited teacher-directed inquiry instruction. Participants *did* assume an active role; they asked scientifically-oriented questions to initiate inquiries, allowing students to collect data, explaining the activities in terms of evidence and connected activities to scientific knowledge. But during such teacher-directed enactment, students’ roles mostly became limited to following instructions and gaining knowledge from their *teachers* rather than learning by interpreting evidence by themselves as encouraged by the NRC (2000). Participants also interpreted their enactment of inquiry instruction quite differently than theoretical insights (as in Bell et al., 2005 or NRC, 2000). The discrepancy in rating the level of inquiry enactment stemmed from different interpretation of the amount of guidance provided by teachers during inquiry. Some participants described adaptations of inquiry instruction during their enactment of inquiry instruction.
As to the third research question, participants mostly held positive views about teaching using inquiry. While many identified benefits of inquiry learning to students and teachers similar to views held by the NRC (2000), they also expressed some unique perspectives towards teaching science using inquiry to learners with disabilities. Participants expressed how inquiry-based teaching and learning could be difficult to certain students or teachers in special education. Despite these challenges, participants believed that inquiry instruction needed to be and could be adapted to accommodate diverse learners in the classroom. Participants provided only modification strategies for questions and hands-on activities. While expressing their views, participants often referred to their previous science learning experiences that they considered not inquiry-based, even though they preferred learning by inquiry as students of science. To most of them, this course came as their first inquiry learning experience.

For the fourth research question, the participants in general willingly used inquiry in their future science classrooms but chose to do so by perceiving the diverse benefits of inquiry learning, resulting in only some matching the theoretical insights provided by the NRC (2000). Participants indicated a variety of instructional settings where they envisioned using inquiry. Many participants’ future plans connected to the way they understood inquiry. Participants expressed the lack of science content knowledge to be the main source of concern for their future practice of inquiry, though a few others designated other barriers to future practice such as the lack of time and resources and lack of science teaching opportunities in future classrooms.
From these results, it becomes evident that participants constantly brought their previous science learning experiences and experiences in special education to learning experience of inquiry and its features (NRC, 2000) as learned in the science methods class. As a result of these influences, participants conceptualized inquiry somewhat differently from that outlined by the NRC. But such interpretations can possibly bring new insights to learning and teaching of inquiry in diverse classrooms and are discussed in the next chapter.
CHAPTER V
DISCUSSION AND FUTURE IMPLICATIONS

This chapter examines how preservice special education teachers understood (specifically, how they defined, characterized inquiry), enacted inquiry instruction, viewed inquiry, and planned for teaching inquiry in science. Sixteen preservice special education teachers from four different special education concentrations undertook multiple opportunities to experience inquiry in an NRC-aligned K–8 general science methods course. Qualitative data representing participants’ own thoughts and actions were collected and qualitatively analyzed (Merriam, 2009; Strauss & Corbin, 1990) and compared against the NRC’s (2000) version of inquiry, the results of which appear in this chapter. In addition, implications for teaching and research are provided.

This chapter is organized as follows: I start by revisiting the key results of the research, question by question, tying results to previous literature, and identifying new insights appearing from the present study. Next, I discuss how such results might have come about and propose a conceptual model for teaching inquiry to preservice teachers that stem from the results as well as previous literature. I expand this conceptual model in terms of present results and previous literature. Finally, I provide implications for teaching and future research with reference to the model and end this chapter acknowledging the limitations of this qualitative research study.

Analysis of Findings

This study aimed to address two purposes: (a) to identify how special education teachers understand, enact, view, and plan for inquiry; and (b) to compare participants’
understandings, enactments, views, and plans to the version of inquiry provided by the NRC (2000). Results indicate that participants’ interpretations of inquiry held both matches and mismatches when compared with the NRC’s version. These matches and mismatches became evident in all areas of inquiry (understandings, enactments, views, and future plans) as explored in this research. Participants brought their previous science learning experiences and experiences in special education to interpret learning about inquiry as experienced in the studied methods class.

**Defining and Characterizing Inquiry**

Participants clearly demonstrated an understanding of an active role of learners during inquiry-based learning. They articulated that inquiry differed from traditional forms of science learning (inquiry was not memorizing science content), an understanding not previously reported in special education teacher candidates. Comparing their definitions (descriptions of *what inquiry is*) and characterizations (descriptions of *how inquiry is done*) against the NRC (2000) revealed certain similarities as well as differences. To a lesser extent, participants defined and characterized inquiry from the learner’s perspective as shown by the NRC. Many times they explained inquiry from the teacher’s perspective, describing how teachers can use inquiry and its features (NRC, 2000) to teach students by inquiry. The conflating of inquiry learning with inquiry instruction is a problem also found with preservice general science teachers who have similar methods class experiences (Crawford, 2007; Haefner & Zembal-Saul, 2004; Kang et al., 2013, Plevyak, 2007; Varma et al., 2009; Windschitl, 2003, 2004). The same problem that appeared in the studied participants can also be due to struggle in
differentiating inquiry learning from inquiry instruction, commonly found in science teachers. Even so, there can be an alternate explanation for conflation of inquiry learning with inquiry instruction. These participants, being preservice teachers in special education, interpreted inquiry as a teacher-guided process of learning and thus conflated inquiry learning with inquiry instruction. The fundamental principle of guiding students with disabilities toward better learning (Abels, 2014; Rumrill et al., 2001, Rumrill et al., 2011) also applies while teaching science using inquiry (Abels, 2014). Being preservice teachers in special education, the participants, looked at practicing inquiry with students with disabilities only and failing to understand that inquiry learning can be conducted in diverse instructional settings. Participants seldom expressed that inquiry can also be accomplished in different ways including a student-centered way as envisioned by the NRC (2000) which is consistent with the second purpose of the study.

The two influences (conflating inquiry learning with inquiry teaching and viewing teaching of inquiry only to students with disabilities) possibly led to misinterpretations about the purpose of inquiry and its features (NRC, 2000) as provided by participants. A stronger understanding of inquiry and its features (NRC, 2000) along with science learning in various instructional settings (Bouck, 2007; Vannest et al., 2009) can address some of the misconceptions about inquiry and its features (NRC, 2000) found in the study participants, who represented teachers whose inquiry conceptions have not been studied before. For example, participants juxtaposed asking scientifically-oriented questions that lead to data collection and analysis (an NRC feature of inquiry) with asking questions to assess prior knowledge and learning in students, which are some
ways to guide or facilitate students learning by inquiry. While teachers can use guided questioning to assess prior knowledge, direct students’ thoughts and assess student learning as well as support teaching science to students with disabilities (see NRC, 2012, Appendix D), such questioning does not hold the same meaning as questioning feature of inquiry that prompt data collection and analysis, a fundamental concept of inquiry. Again, while guided questions from special education teachers can support inquiry instruction with certain students with disabilities (Dalton et al., 1997; Mastropieri et al., 1997; McCarthy, 2005; Palincsar et al., 2000), they differ from the questioning feature of inquiry (NRC, 2000). Participants need to understand the difference to facilitating the sense-making while practicing inquiry with students with disabilities (Abels, 2014). Moreover, a lack of understanding the five features (NRC, 2000) can prevent special education teachers from developing appropriate adaptations. For example, merging features such as formulating of explanations from evidence, connecting explanation to scientific knowledge and communicating and justifying explanations, as found in the study participants, could be due to lack of understanding of the features separately. It can be possibly due to such an incomplete understanding of inquiry and its features (NRC, 2000) that participants struggled with practicing certain features or differentiating them for learners in the classroom. Since special education teacher candidates in the future can teach science in a variety of instructional settings (Irving et al., 2007; Vannest et al., 2009), understanding of the five features (NRC, 2000) can likewise support their understanding of the variations (NRC, 2000) that exist along the teacher-learner continuum. Depending on the instructional setting, questions, methods, or solutions for
inquiry investigations can come from the teachers (Bell et al., 2005). This can be applicable to teachers in special education who can provide variable amounts of teacher guidance and still practice learning by interpreting evidence as encouraged by the NRC (2000). While some settings likely need several features to be practiced by the teachers, other settings could have students capable of practicing features by themselves. Moreover, as reflected in the participants’ responses, some instructional settings might need stronger adaptation of the five features (NRC, 2000) than others depending on students’ needs and abilities. Understanding the five features (NRC, 2000) can instruct special education teachers about the variations in amount of teacher guidance applicable in different instructional settings and adapt them accordingly.

An incomplete understanding of scientific inquiry (NRC, 2000) can lead to incomplete understanding of the Scientific and Engineering Practices in the new Framework (NRC, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013). This is because the NRC’s five features are also embedded in the Practices (Crawford, 2014; Figure 5).

With special education teachers, an incomplete understanding of inquiry and its five features (NRC, 2000) could lead to incomplete or incorrect adaptation of inquiry instruction as found in the present study’s participants. This problem of misinterpreting the features of inquiry needs to be addressed by the methods class instructor for future special education majors who take this course.
Enacting Inquiry Instruction

As to Research Question 2, participants’ enactment of inquiry instruction revealed a strong influence of the role of teacher-guidance, similar to the findings for Research Question 1. In their enactment, all groups demonstrated a conscious effort to use all five features of inquiry (NRC, 2000). Such enactments may or may not indicate an understanding of inquiry because these enactments could result from merely following the instructions for the inquiry microteaching assignment. But even if participants obtained lesson plans from a secondary source (such as book or the Internet), they still had to organize their lesson’s instructional sequence using the Learning Cycle (Bybee, 2000) and they need to teach using the NRC (2000) guidelines. While participants’ enactments did demonstrate the *abilities* (what is done) described in the features (NRC,
2000), they failed to demonstrate an understanding of who (teacher/learner) engages in those features (NRC, 2000) during inquiry (Figure 6).

<table>
<thead>
<tr>
<th>Less emphasis</th>
<th>More emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Learner engages by scientifically-oriented questions,</td>
<td></td>
</tr>
<tr>
<td>ii) Learner gives priority to evidence in responding to questions;</td>
<td></td>
</tr>
<tr>
<td>iii) Learner formulates explanations from evidence</td>
<td></td>
</tr>
<tr>
<td>iv) Learner connects explanations to scientific knowledge</td>
<td></td>
</tr>
<tr>
<td>v) Learner communicates and justifies explanations.</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 6.* Emphases in participants’ enactments of inquiry instruction.

The NRC (2000) has been criticized previously for overly emphasizing the *doing* part of inquiry at the expense of learning *about* inquiry (Anderson, 2002). This type of thinking created difficulties with the enactment of inquiry instruction reported in preservice general science teachers (Crawford, 2007; Hancock & Gallard, 2004; Leonard et al., 2009; Windschitl, 2003), and the same difficulty appeared with this study’s participants. Furthermore, as beginning teachers, the participants demonstrated eagerness to use of all five features, failing to understand that teacher use of the features limits the student’s role in inquiry (see Figure 5). Also, while aiming to use all five features (NRC, 2000), but doing so as teachers of science rather than encouraging their learners to use the features, the studied participants enacted teacher-directed inquiry instruction.

Although teacher-directed enactment of inquiry has also been previously reported in preservice general science teachers (Crawford, 2007; Hancock & Gallard, 2004;
Leonard et al., 2009), this type of enactment can be appearing in this particular group of participants due to entirely different reasons. Participants not only interpreted their inquiry teaching differently than theoretical perspectives (Bell et al., 2005; NRC, 2000), but also interpreted the amount of guidance during inquiry differently than the NRC (2000) or Bell et al., (2005). For example, participants provided step-by-step procedures but did not feel that they did so while classifying their enactment (as revealed in their reflections). One possibility could be that participants being teachers in special education, and considering teacher’s guidance to be a part of inquiry, analyzed data and drew scientific explanations for their students while thinking this as a responsibility of teachers. Alternately, probably because of their status as teachers in special education, they used the NRC (2000) features more than once during their inquiry enactment and considered such enactment to reinforce learning. This also can be the reason behind participants being quite inclined to bring adaptation of inquiry instruction during their enactment. The five features (NRC, 2000) do not explicitly address adaptation of inquiry for students with disabilities. But these participants, being teachers in special education, enacted a teacher-guided inquiry instruction that resembled inquiry instruction in classrooms with students with disabilities (Abels, 2014; Dalton et al., 1997; Mastropieri et al., 1997; McCarthy, 2005; Melber & Brown, 2008; Palincsar et al., 2000; Schmidt et al., 2002; Scruggs et al., 1993). The participants’ enactments of inquiry instruction failed to demonstrate an understanding of this dichotomy in both value and the amount of teacher-guidance while teaching science using inquiry.
Views on Teaching Science Using Inquiry

In regard to Research Question 3, participants held mostly positive views about teaching science using inquiry. Some of the benefits matched the NRC’s (2000) vision and others indicating new usefulness of the features NRC. The participants conveyed that inquiry learning improved understanding and engagement in science, promoting critical thinking and motivation in students, their views matching the NRC’s rationale. Such positive views are also found in preservice general science teachers (Crawford et al., 2005; Davis, 2006; Duncan et al., 2010; Plevyak, 2007; Santau et al., 2014; Ucar & Trundle, 2012; Varma et al., 2009) who perceived the benefits of inquiry.

The positive views mostly stemmed from participants’ previous science learning experiences, which was both similar to and different than studies reported with preservice general science teachers (Hancock & Gallard, 2004; Windschitl, 2003, 2004). For instance, previous science research experiences have strengthened preservice teachers’ understanding of inquiry learning in methods class as found in Windschitl (2003). The participants’ science learning experiences have contributed toward making them aware that inquiry instruction differs from lecture- and textbook-based instruction in science. On the contrary, Hancock and Gallard (2004) reported than general science teachers conceptualized inquiry as teacher-directed mode of instruction stemming from their science learning that occurred by transmission (information passed from teacher to student). Windschitl (2004) found that preservice secondary teachers develop several misconceptions (“folk theories”) about inquiry from books, the media, and even from faculty with whom participants interacted as students. In this study, participants brought
both their previous science learning experiences and experiences in special education to understand and view inquiry. Drawing from their previous learning experience, participants understood how inquiry learning differed from traditional, lecture-based methods of learning and science. This result contrasted findings in earlier science education literature where teachers from the methods class actually portrayed inquiry as a one-way, teacher-directed form of learning stemming from the ways they learned science (Hancock & Gallard, 2004; Windschitl, 2004).

Drawing from their experiences in special education, participants viewed certain additional benefits of inquiry. Participants considered inquiry to provide multisensory experience to learners as previously reported in inquiry studies conducted with students with disabilities (Bancroft, 1999; Mastropieri et al., 1997; McCarthy, 2005; Melber & Brown, 2008; Palincsar et al., 2000; Schmidt et al., 2002). Drawing from their backgrounds in special education, participants identified why inquiry learning can be difficult for some students in special education (students with lower cognitive abilities or students with certain physical impairments) and can be difficult to plan and implement for some teachers in special education (balancing of needs in learners, identifying learners’ needs). The difficulty in practicing inquiry due to the lack of time and resources, a view previously reported by preservice science teachers (Crawford, 2007), rarely appears in these participants. This result could be that participants, being teachers in special education, saw certain other factors (such as meeting diverse learners’ needs during inquiry instruction) as more important during practice of inquiry rather than factors (like time and resource limitations) found in teachers teaching inquiry in general
education settings. Another possibility could be that the participants were still preservice teachers who are yet to practice inquiry-based teaching in actual classrooms and thus may not be fully aware of what it means to teach using inquiry. Participants abundantly indicated certain factors necessary to address while teaching science to students with disabilities using inquiry previously suggested by Abels (2014).

Another important result in this section was that of the participants’ understandings of adapting inquiry instructions. While a number of participants identified that inquiry needed to be adapted to accommodate diverse learners in the classroom, many expressed that inquiry could be adapted to accommodate diverse learners in the classroom. The possibility and benefit of adapting inquiry instruction as perceived by preservice special education teachers themselves does not appear in any earlier literature on inquiry and is a potential way that this study adds to the present literature base on inquiry. Here, the participants provided modification strategies for asking questions and hands-on activities, but not other NRC (2000) features of inquiry. Absence of adaptations for other features may appear due to participants’ lack of understanding of the five features as found earlier in the study, or even due to difficulties in developing those adaptations. While empirical support exists for prospective special education teachers perceiving the need and the possibility for adapting inquiry, both teaching and research can be expanded to adaptations of other features.

**Future Plans With Inquiry**

In addressing Research Question 4, participants in general all willingly incorporated inquiry in their future science classrooms, but they chose to do so after
perceiving the diverse benefits of inquiry. Not all of these benefits matched the benefits conveyed by the NRC (2000). Rather, the participants’ future plans of practicing inquiry closely resembled the ways they conceptualized and practiced inquiry now. In one example, a participant who conceptualized inquiry to incorporate a multi-sensory experience was willing to incorporate inquiry in her future classroom because she believed inquiry would give her students a multisensory environment. Participants not only developed various interpretations of inquiry while learning about it in this methods class but harbored such interpretations and planned to take these interpretations with them to their future classrooms. If their understandings remain incomplete or inaccurate as found in some of the participants, a possibility exists that these misunderstandings could be enacted in future classrooms, thereby limiting the benefits of inquiry.

While sharing their future plans, participants reported a variety in instructional settings in which they envisioned teaching using inquiry. But none of the participants indicated an awareness of diversity in instructional settings that may exist while teaching science to students with disabilities (Bouck, 2007; Vannest et al., 2009). In some settings, participants might have to teach science individually; they might otherwise teach in collaboration with other teachers (Bouck, 2007; Vannest et al., 2009). Some of the participants chose to co-teach in the future to escape content teaching. Still, co-teaching involves the sharing of all teaching responsibilities, including the teaching of content (Bouck, 2007; Vannest et al., 2009). Co-teaching during the preservice phase might not be successful since general education teachers and special education teachers often maintain separate beliefs and theoretical frames and thus fail to work in collaboration
with one another successfully (Arndt & Liles, 2010). Partnership between science education and special education preservice teachers can make candidates aware of each other’s roles and expectations and may support both to meet the diversity in needs and abilities in future students.

Finally, a strong understanding of the idea that inquiry cannot be practiced without adequate content knowledge was found in each of the 16 participants. These participants expressed their lack of science content knowledge as a concern to their future practice of inquiry. Lack of science content knowledge can impede the practice of inquiry (NRC, 1996, 2000), a problem also reported in general science teachers (Appleton, 2006; Crawford, 2007; Lustick, 2009; Santau et al., 2014). Participants recognizing and acknowledging this lack of science content knowledge as a barrier to successful teaching of inquiry is a key strength of this study. Expressing such a concern conveyed that these participants were aware that their lack of science content knowledge could create a problem with inquiry instruction. An awareness of the lack of science content at this early stage of the teacher preparation phase could give participants a better position than preservice teachers who may not identify this weakness and thus struggle to use inquiry (Lustick, 2009; Santau et al., 2014). Allowing teachers to plan and deliver inquiry instruction using inquiry with the Learning Cycle (Bybee, 2000) and NRC (2000) guidelines have been found to increase science content knowledge in preservice general science teachers (Santau et al., 2014). Similar results presented themselves in the present participants who could draw scientific explanations from evidence during their inquiry microteaching.
Teaching Preservice Teachers About Inquiry: A Proposed Model

The results of the study indicate that similar to preservice general science teachers (Crawford, 2007), teaching science using inquiry also creates a complex enterprise for special education teachers as well. Prospective special education teachers who undergo similar inquiry learning experiences as prospective general science teachers in NRC-aligned science methods classes bring their previous knowledge and experiences in both science and special education to their learning about inquiry and the five essential features (NRC, 2000). These experiences influence the way the teacher candidates understand, enact, view, and plan for inquiry.

The results of this qualitative study develop a conceptual model for learning to teach science using inquiry. The model identifies three components relevant to learning teaching and adapting inquiry. These three components are: (a) The Learner; (b) The Teacher; and (c) The Instructional Setting (Figure 7). While the NRC (2000) described variation of inquiry along the teacher-learner continuum, this model claims that the variations in instructional setting play a crucial role in inquiry-based learning and teaching and that the variations along teacher-learner continuum changes with changes in the instructional setting. Notably, the model remains hypothetical and has been developed collectively from the results as found in this study, previous empirical literature and theoretical constructs of inquiry as proposed by the NRC (2000).
Figure 7. Teaching preservice teachers about inquiry: A proposed model.

The Learner

In this model, the learner assumes an active role and engages in firsthand, direct experiences with the science concept being studied. The learner component also includes engagement and enjoyment in science and students taking ownership of their learning while engaging in various experiences. Such experience can include learning by interpreting evidence, a vision strongly encouraged by the NRC (2000). The learner component is particularly important to special education teachers while teaching about
the five features (NRC, 2000), since special education teachers (as seen in my participants) should understand the importance of what is done during inquiry, but may overlook who engages in the doing in true inquiry environment. This can be also taken to teaching about the Practices (NRC, 2012), which are also written from the learner’s perspective (what students need to do while learning science today). Learning by inquiry would support development of scientific reasoning in students using evidence and logic (NRC, 2012) and allows students to evaluate multiple possible answers in science (Roth, 1995, 1996). Inquiry supports development of argumentation skills in students using data collection and analysis as encouraged in the Common Core State Standards (National Governors Association, 2010). Following teaching about both the features and identifying who engages in those features, however, it can be informed that both learner’s understanding and practice of inquiry would vary with the instructional setting in which inquiry is being conducted. While some settings could have students who grasp these concepts easily, some students with disabilities would likely struggle with practice of the features, requiring stronger adaptation from teachers.

**The Teacher**

In this model, the teacher acts as the provider of guidance for meaningful learning by inquiry. An understanding of the five essential features (NRC, 2000) can lead teachers to identify practices that students need to engage while learning by inquiry and how much support students need to accomplish learning by inquiry. A stronger understanding of the five features (NRC, 2000) or the Practices (NRC, 2012) allows teachers to guide students to support the development of the abilities of scientific
reasoning, an important aspect of science education today (NGSS Lead States, 2013; NRC, 2012). Teaching using inquiry cannot be accomplished without appropriate science content knowledge (Appleton, 2006; NRC, 1996, 2000). Teachers can develop inquiry lesson plans using the Learning Cycle (Bybee, 2000) that should increase content knowledge in preservice teachers while learning and teaching using inquiry (Santau et al., 2014). Variation in the amount of teacher-guidance can be taught using existing theoretical frameworks (Bell et al., 2005; NRC, 2000), indicating that the amount of teacher-guidance varies from setting to setting and some students probably need more support to understand learning by inquiry than others. The planning and execution of inquiry might need time and certain resources (Crawford, 2007), and teachers need to plan accordingly for time and resources management.

Here again, the amount of support from teachers not only differs due to diverse abilities in students, but it also depends on what instructional setting the learning takes place. The variations along the teacher learner continuum is equally important to special education teachers who would have to play a stronger role in currently providing the guidance necessary to make science learning relevant to students with disabilities (Scruggs et al., 2013). Teachers, depending whether they teach individually or in collaboration (Bouck, 2007; Vannest et al., 2009), may assume different roles while supporting student’s learning by inquiry.

The Instructional Setting

Science teaching of special education students can occur in diverse educational settings (McGinnis & Kahn, 2014; Vannest et al., 2009). There is not only diversity in
abilities of students but diversity in instructional settings where these learners are placed (McGinnis & Kahn, 2014). Some settings can require special education teachers teaching individually and some in collaboration with general science teachers (Bouck, 2007; Therrien et al., 2011; Vannest et al., 2009). Thus, not only the abilities of learners in engaging in inquiry and the five features (NRC, 2000) can differ in certain settings, the guidance provided from teachers in inquiry environment can also change with the roles of teachers in the classroom. In addition, even inside a classroom, students’ needs and abilities could vary at multiple levels or might have more than one disability, making differentiating of instruction difficult for students with disabilities (Rumrill et al., 2011).

Participants indicated that students with disabilities could require special accommodations (i.e., physical accommodations such as a wheelchair, quiet environment, or other accommodations depending on their disabilities), and these can affect the ways inquiry is enacted in the classroom. While in certain settings, students may benefit from inquiry learning in certain settings such as students with mild to moderate disabilities placed in an inclusive setting (supported by empirical studies and recognized by the present study’s participants), inquiry may be difficult with certain students such as those with moderate to intense disabilities, students with severe disabilities (informed by the present participants but not supported by enough empirical research). Students with disabilities who form a large portion of student population in public schools today (U.S. Department of Education, 2012) have not been empirically studied when it comes to teaching of science (Courtade et al., 2007; Therrien et al., 2011; Scruggs et al., 2013). This can apply to teaching of science using inquiry and make
inquiry learning and teaching a complex endeavor for students in special educations who find themselves placed in diverse instructional settings.

**Implications for Teaching**

Interpreting inquiry (as in NRC, 2000) through lens of preservice special education teachers reveals that elements in the learner and the teacher component can change and take different dimensions depending on the elements in the instructional setting. Incorporation of instructional setting elements into the classical teacher-learner outlook of inquiry (NRC, 2000) indicates that practice of inquiry can take different forms with changing students and teachers, presenting a stronger case for adapting inquiry for students in diverse instructional settings. The proposed conceptual model represents how teachers in special education experience tensions that appear while practicing science as inquiry as a result of differences in theoretical viewpoints in science education and special education previously hinted by McGinnis and Kahn (2014). For example, the model explains why the amount of teacher-guidance can be different in a particular instructional setting that has a particular type of learners. This possibly can allow teachers to identify to understand their roles in that setting and adapt the amount guidance appropriate in that particular setting. While it is extremely difficult to generalize teaching in itself, whether teaching students with or without disabilities (Abels, 2014), generalizing instruction in the special education context is even more difficult due to the complex nature of special education itself (Rumrill et al., 2001), the model can be used to teach and explain that difficulty to prospective teachers, even if not directly addressing the difficulty.
Even before the model, a rationale for teaching preservice teachers (both preservice general science teachers and preservice special education teachers) about inquiry emerges from the following assertions. Teaching science as inquiry still differs from traditional modes of teaching and learning of science, which involves passive, one-way transmission of knowledge from teachers to students (Barrow, 2006). Instead, inquiry involves students learning by direct authentic experiences using scientific reasoning (NRC, 2000, p. 21). Inquiry allows students to explore the wrong answers, which in turn, allows students to justify their answers, thereby supporting their learning (Crawford, 2014, p. 519). Even in the new standards, the NRC states that “knowing why the wrong answer is wrong can help secure a deeper and stronger understanding of why the right answer is right” (NRC, 2012, p. 44). Inquiry thus continues to remain important in the era of Practices (NRC, 2012) since both are inter-related (Crawford, 2014) and both call on learners to actively construct scientific knowledge by direct, authentic experiences (Crawford, 2014; Osborne, 2014). The replacement of “inquiry” with “Practices” occurred “to make inquiry more applicable” (NRC, 2012, p. 2), clearly indicating the continuing efforts of NRC to encourage this mode of learning and teaching in science. The Scientific and Engineering Practices (NRC, 2012) still embody the conceptualizations originally outlined by the NRC (1996, 2000; NGSS Lead States, 2013, p. 301). Because of this, the NRC (2000) document could be a starting point for teaching teachers about inquiry and they could expand to practices (Crawford, 2014). Additionally, inquiry-based learning involves learning by giving priority to evidence-based lessons (Barrow, 2006), which resonates with evidence-based learning found in the
current Common Core State Standards that encourages students to answer research questions by drawing upon evidence from various sources and engaging in data analysis and argumentation (National Governors Association, 2010). If teachers are prepared about inquiry-based practices, they can support the development of the abilities to conduct inquiry in their students.

Learning about inquiry in preservice teachers can be conducted during the preservice phase (Capps et al., 2012), a fundamental phase in science teacher preparation (Luft, 2007, 2010). Science methods courses that have been effective platforms to prepare general science teachers about inquiry (Crawford et al., 2005; Davis, 2006; Duncan et al., 2010; Kang et al., 2013; Kim & King, 2012; Leonard et al., 2009; Lustick, 2009; Plevyak, 2007; Santau et al., 2014; Ucar & Trundle, 2012; Varma et al., 2009; Windschitl, 2003; 2004; Yoon et al., 2012) can be a platform for learning about inquiry to preservice teachers in special education as found in this research. Positive outcomes such as enhanced learning of science content (Crawford et al., 2005; Santau et al., 2014; Ucar & Trundle, 2012) and increased understanding student-centered science teaching (Plevyak, 2007; Varma et al., 2009) are also found in the study participants. Furthermore, special education teachers with unique backgrounds and experiences brought new insights to the need and complexity of learning, teaching and adapting inquiry by placing importance to the instructional setting in which inquiry is conducted, a variety that is previously reported indicating variety of roles of teachers in them (Abels, 2014; Bouck, 2007; Irving et al., 2007; Vannest et al., 2009).
An understanding of the five essential features (NRC, 2000) can lead teachers to identify practices that students need to engage in for developing abilities of scientific thinking and reasoning, a critical component of science education today (NGSS Lead States, 2013; NRC, 2012). This can be equally important to special education teachers who play a more significant role in providing additional guidance to make science learning relevant to students with disabilities today (Scruggs et al., 2013). Although a large variation exists among students in special education, which could result in translating learning into practice (Rumrill et al., 2011), special education teachers could still be given the same opportunity to learn about this form of experience-based education and understand inquiry with the three components as identified in the conceptual model (see Figure 6).

The following recommendations would support future methods instructors for teaching prospective teacher candidates (either in general science or in special education) to learn about inquiry using the model (as in Figure 7) although some of these suggestions may not apply for certain students with disabilities (such as students who lack verbal language skills or adequate motor or cognitive skills to participate in inquiry). The first effort would be emphasizing the learner component of the model, a key emphasis in present-day science learning (NRC, 2012; NGSS Lead States, 2013). Teacher candidates can be reminded that both Practices (NRC, 2012) and essential features (NRC, 2000) are written from the learner’s perspective and students take part in their own learning by direct experiences (Crawford, 2014; Osborne, 2014). Teacher candidates can engage in inquiry-based activities in methods classes where they get to
experience inquiry as learners of science themselves to possibly understand what is envisioned in the features (NRC, 2000). Such experiences have previously supported learning of science content in preservice general science teachers (Crawford et al., 2005; Santau et al., 2014; Ucar & Trundle, 2012) and also appeared in my present data. Such experiences have promoted understanding and engagement in science (Plevyak, 2007; Varma et al., 2009), similar to benefits identified by the present study participants. Here, with reference to the model, teacher candidates can be encouraged to reflect on inquiry learning with reference to the diverse learners’ needs and abilities and the amount of support learners might require to accomplish learning by inquiry.

After experiencing the inquiry as learners of science, teacher candidates can be led to experience inquiry as teachers of science. Future teacher candidates can also engage in teaching small science lessons using inquiry using the Learning Cycle (Bybee, 2000) that have supported increase in science content knowledge (Santau et al., 2014), and also in the participants. Microteaching experiences supported planning of inquiry-based lesson plans, enacting inquiry instruction in front of their peer posed as students and reflecting on such initial teaching experiences. These enhanced science teaching skills, previously reported in general science teacher candidates (Varma et al., 2009), are also found in the present study’s participants. Variations in the amount of guidance can be to learners using the NRC (2000) document and data from this research. For example, methods instructors can provide the statement, “scientific inquiry is asking questions to students so that they can lead to their own experiences” (an image of inquiry held by one of the study participants) and ask future students if they think that this is inquiry learning
or inquiry teaching. This type of prompt should lead to discussion about the variations of inquiry along the teacher-learner continuum (NRC, 2000) and permit any preservice teacher (not just teachers in special education) to different ways inquiry is practiced. For future teachers in special education, such discussion would include reference to the variety of instructional settings that are best suited for certain variations and identify challenges to the practice of inquiry in certain settings and with students with severe disabilities.

Data from this study may be used to develop several vignettes (Merriam, 2009) to better understand teacher-guidance during inquiry instruction. For example, a vignette from Kim, Carol, and Emily’s enactment could be used to ask future students to interpret the level and type of inquiry instruction. A model assignment is described in Figure 8.

<table>
<thead>
<tr>
<th>Understanding Enactment of Inquiry Instruction: A Vignette</th>
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<tbody>
<tr>
<td>Question: What level of inquiry would you allow to the following type of inquiry instruction? Explain and justify your responses from your reflection on Bell et al., (2005).</td>
</tr>
<tr>
<td>T—So do you think we can make ice cream with these materials? What do we need?</td>
</tr>
<tr>
<td>S—The milk.</td>
</tr>
<tr>
<td>T—Right. Where does the milk go? Now pour the milk in the small Ziploc bag. What do we do next?</td>
</tr>
<tr>
<td>S1—Add sugar.</td>
</tr>
<tr>
<td>S2—Add salt.</td>
</tr>
<tr>
<td>T—Do you think we should add the salt to the milk? Is ice cream sweet or salty? It’s the sugar. Go ahead, now add the sugar to the milk. Also, add 1 spoon of vanilla too.</td>
</tr>
</tbody>
</table>

**Figure 8.** An example of a vignette to understand inquiry instruction.

Such analysis may encourage not just special education teachers but all future teacher candidates to understand the difference between *giving* students step-by-step procedures versus allowing students to *develop* their own procedures. This type of
assignment has been previously with general science teachers to instruct them about inquiry (Wagler, 2010) and can complement future teacher candidates’ learning about the levels of inquiry. Enactment of inquiry instruction has always been a problem with preservice teachers, both for general science preservice teachers (Crawford et al., 2007; Leonard et al., 2009) and for special education teacher candidates, as found in the study. Such an assignment will support better understanding about the role of teachers during inquiry instruction and can prompt teachers to become more student-centered in their instruction.

Finally, teacher candidates may explicitly reflect on the instructional setting in which inquiry learning can be conducted (referring back to the model). This would engage teachers to discuss that inquiry may not be uniformly possible in all classrooms. While some students might need smaller amount of guidance from teachers to accomplish students’ learning by inquiry, some could need more assistance and some may fail to learn by inquiry despite teacher’s guidance. This variation in students’ needs and abilities should also allow teacher candidates to understand the need and complexity of adaptation of inquiry instruction, the lack of which is lamented in both science and special education (Therrien et al., 2011) and also recognized in the present study participants. Specifically, for special education teachers who do not possess adequate ideas about teaching science in general classrooms, classroom videos from educational websites (Engineering is Elementary developed by Museum of Science, Boston is an example) can be screened to conceptualize inquiry teaching in general science classrooms. Preservice teachers could be asked to interpret the level of inquiry in the observed videos. Such assignments can be
valuable to special education majors who would be given the opportunity to observe inquiry in general classrooms and broaden their understanding of teacher-guidance during inquiry in general classrooms and not just teaching students with disabilities.

Teacher candidates could be informed that future possibilities of teaching science can be conducted individually or in collaboration with other teachers (Bouck, 2007; Vannest et al., 2009). Reading Bouck (2007) would allow both general science and special education teacher candidates to understand that co-teaching requires sharing all responsibilities including the teaching of content. Inviting preservice general science teachers from a parallel science methods courses to work closely with preservice special education teachers to plan and deliver science lessons for inclusive classrooms is recommended. Students interacting with each other will probably gain insight about each other’s theoretical frameworks that may strengthen their perceptions of and abilities to engage in co-teaching (Arndt & Liles, 2010). While special education teachers from such partnership can develop better understanding of adapting inquiry, such partnerships could lower anxiety in preservice general science teachers to teach students with disabilities in inclusive classrooms (as reported by Everhart, 2009; Gately & Hammer, 2005; Irving et al., 2007; Shippen et al., 2005).

Finally, I would suggest an active partnership between the departments of science education and special education at the university. This general science methods class can invite experts in special education to provide better insights on differentiation of instruction, particularly science instruction to future students. Teacher candidates can read Individualized Education Plans (IEPs) and discuss modifications for instruction with
reference to the specific accommodations needed. This will not only support special
education teachers who may teach science individually or co-teach in general classrooms
but also support any preservice general science teachers who may have learners with
IEPs. Such interactions may compliment instruction about adaptation as conducted in
this methods class and strengthen participants’ understanding of differentiating inquiry
instruction. Empirical support regarding such efforts remains extremely rare and could
provide valuable insights for teacher educators of both science and special education
teachers.

A general science methods course such as this can be placed earlier in preservice
special education teachers’ programs so that future students can apply their learning to
other classes, a recommendation appearing from benefits perceived by only two of the
study participants. This model (as in Figure 7) would be particularly helpful to address
potential misconceptions about inquiry as found in the studied preservice special
education teachers whose inquiry conceptions have not been previously reported and may
teach science to students in certain future settings.

Implications for Future Research

Convinced by the empirical studies that approved learning of inquiry in preservice
general science teachers (Crawford et al., 2005; Davis, 2006; Duncan et al., 2010; Kang
et al., 2013; Kim & King, 2012; Leonard et al., 2009; Lustick, 2009; Plevyak, 2007;
Santau et al., 2014; Ucar & Trundle, 2012; Varma et al., 2009; Windschitl, 2003, 2004;
Yoon et al., 2012), I allowed special education teachers to undergo similar methods class
experiences. Considering that either experiencing inquiry as learners or teachers of
science alone might not be enough to prepare teachers about inquiry instruction (Kang et al., 2013; Lustick, 2009; Yoon et al., 2012), I provided students with opportunities to experience both. I was not fully aware, however, of how their special education background and experiences would direct their thinking about inquiry and what interpretations of inquiry could result from such influences. I would like to expand on such outcomes of learning about inquiry in future teacher candidates using further research. I would also like to investigate how effective inquiry instruction will be for students with different degrees of disabilities.

One research possibility would entail teaching future special education teacher candidates about inquiry using the recommendations provided above and then shadowing them during their student teaching. It would be interesting to see the types of future instructional settings in which these special education teachers are placed and how inquiry instruction happens in such settings. Such a study should provide valuable insights on the enactment of inquiry in diverse instructional settings that may exist while teaching science to K–8 learners. Previously, Vannest et al. (2009) reported a combination of 10 different instructional settings in fourth grade in one studied school district in Texas. Following future candidates in the field will reveal the diversity in instructional setting offered to the study participants and better inform methods instruction to support inquiry learning across contexts.

Following candidates to their field placements allows researchers to study their enactment of inquiry and track changes in their understanding of inquiry teaching from methods class to field teaching. Preservice general science teachers have reported
problems with teaching using inquiry (Crawford, 2007; Leonard et al., 2009). It would be interesting to see how these teachers enact inquiry instruction in the field and if they also report similar problems. A study of their future inquiry instruction could help teacher educators to understand the factors associated with inquiry-based teaching when implemented with learners with disabilities. Some of the factors reported by the present pool of participants were learners’ needs and abilities, opportunities to teach science, and time and resource management. Following these teachers into the field should provide insights on how to prepare special education teachers to develop effective inquiry instruction around such factors that influence their teaching in the field.

Another future research project could involve interviewing participants following their field experience to explore their thinking about inquiry. Such interviews can reveal whether or not participants are given the opportunity to use inquiry while teaching science (or any other subjects) and how they interpret their enactment. Such a study might also include changes in their views of teaching science using inquiry. Special education teachers may reveal teaching using inquiry to be a complex enterprise as found in preservice general science teacher candidates (Crawford, 2007).

A third future direction in research could entail preservice teachers’ learning about science content knowledge following learning about inquiry in methods classes. Learning to teach science using inquiry and planning for instruction using the Learning Cycle (Bybee, 2000) increased content knowledge gains in preservice general science teachers (Santau et al., 2014). In the present study, although all the participants expressed their concern about their lack of science content knowledge, they demonstrated...
good understandings of content knowledge during their inquiry-based microteaching.

Certainly, some students may have benefited from adapting content-appropriate lesson plans that they found from other sources. Yet participants still worried about their content knowledge for teaching science. Such a result suggests the need for research that connects development of science content knowledge to learning to teach using inquiry. I would like to assess special education teacher candidates’ content knowledge on specific science topics before and after their lesson planning to see if such practices increase their science content knowledge. This type of research may provide an even stronger rationale for inquiry learning for special education teacher candidates by supporting their development of science content knowledge.

Finally, I would like to conduct similar studies with participants from other special education areas and compare findings. It would be interesting to see how special education majors from other concentrations (such as deaf education, speech pathology, and audiology) construct their knowledge about inquiry-based science teaching. Similar of different images of inquiry from such future studies can provide insights to teacher educators about how to prepare prospective teachers from diverse special education backgrounds to teach and adapt inquiry. Similar studies conducted in methods classes at other universities could develop newer results that thus strengthen or enrich the findings of this study.

**Limitations of the Study**

The limitations of this study are as follows. The first limitation of the study was negotiating my dual role in this project. Critics of this research might claim that
participants’ responses were not fully authentic since they were my students, but the counter includes several strategies that I adopted to address this concern. I made this distinction between the course and the research explicit during the recruitment of participants. I also included several data sources that were not graded assignments in the course (e.g., pre-post questionnaires, interviews). I kept the interviews semi-structured, allowing participants to respond with some flexibility. I conducted these interviews after the course after all assignments were graded and returned to students. In addition, to ensure that all participants responded to topics freely, I conducted interviews in an informal setting and conducted them after the end of the semester, only after I had established a rapport with the participants. The use of multiple sources of data collected at different points throughout the semester provides confidence in my findings.

Nevertheless, I recognize that my dual role in the project could serve as a limitation in that my students might have provided me with more socially-desirable comments.

A second limitation of the study is my own bias toward inquiry and the NRC (2000). To address this limitation, I have remained upfront with my bias while collecting and analyzing data (Merriam, 2009; Strauss & Corbin, 1990). I did not fear to include results that indicate a lack of understanding about inquiry or a negative view about inquiry. I incorporated a grounded theory approach to develop results that appeared from the data and not just reflect my understandings. The open coding technique (Strauss & Corbin, 1990) allowed me to start my analysis from substantial, in-vivo codes that represented the participants’ own words and actions without incorporating theoretical insights or researchers’ insights (Charmaz, 2006), and it served the purpose of ensuring
authenticity and reducing researcher bias during data analysis. Along with open coding, I also employed peer-debriefing and triangulation to enhance trustworthiness of this qualitative study. My own bias toward the concept being studied (i.e., inquiry), however, might have influenced the way I analyzed my data and remain a limitation of this research.

A third limitation lies in the applicability of this research to future practice. The researcher had quite a different background and experiences than that of the study participants. While such differences can sometimes increase the strength of certain qualitative research bringing new and unique insights to concepts being studied (Merriam, 2009), such differences can also cause a disconnect between research and actual practice (Rumrill et al., 2011). Theoretical frameworks completely differ between science education and special education and can develop tension in research on science teaching of learners with disabilities (McGinnis & Kahn, 2014). It is important to acknowledge that positive views are considered positive by the researcher (me) but not be the same to future special education teachers who struggle with practice of inquiry. The positive image of the NRC (2000) is not only coming from teachers who are yet to practice inquiry with actual students, but are coming from teachers who are yet to teach students in special education, some of whom may not have the abilities to engage in these practices in the first place. The idea that inquiry supporting learning in all students as appeared in the study is still an assumption since a lack of research exists in some areas of special education. Further, learning styles of students are different and so are the styles of teaching (Crawford, 2014). Teaching students in special education is even more
complex, and despite honest intentions, research could fail to meet the needs of educators (Rumrill et al., 2011), and can happen with teaching and learning of science by inquiry.

Finally, another limitation of the study is establishing and recognizing the boundaries for the research. I based this qualitative study was based on data collected from 16 preservice teachers in special education selected from two sections of a science teaching methods course in a U.S. public university. These 16 represented only four of the seven concentrations offered at the university—Mild to Moderate majors, Mild to Moderate with Language Arts and Reading (LAR) emphasis, Moderate to Intense majors, and Early Childhood Intervention. No student in Deaf Education, though recruited, agreed to take part in the study, limiting the study to only four self-reported areas of specialization. The participants had specific backgrounds and experiences that influenced their interpretations of inquiry learning, but their interpretations cannot be generalized to all special education majors who have different backgrounds and experiences. Special education majors from different backgrounds and experiences can perceive and practice teaching by inquiry differently.

Admittedly, the methods used in this qualitative research and the results achieved might not be ideal when trying to implement effective instruction for all special needs learners. In the end, each individual teacher must decide which teaching methods to apply in his or her own classroom (Rumrill et al., 2010). Still, the limitations of the study as recognized above should provide possible venues for closely-related research in areas that remain uninvestigated and can use inquiry to aid a greater number of special needs students.
APPENDICES
APPENDIX A

COURSE SYLLABUS
Appendix A

Course Syllabus

CI 47502/57502
Science Teaching in Early and Middle Grades
Spring 2014

114 White Hall
Thursdays, 7.20pm to 10.00pm

Instructor: Rajlakshmi Ghosh (Raj)
Email: rghosh2@kent.edu
Phone: 330-672-2580
Office: White Hall 410
Office Hours: Wednesday 3 to 4pm or by appointment

Course Description:
CI 47502/57502 is designed to provide preservice teachers meaningful and practical learning experience that will prepare them to create effective science learning environments for K–8 students. During this course pre-service teachers will participate in hands-on & minds-on activities, reading, writing & reflection, group discussions, presentations, and designing & micro-teaching inquiry-based lessons.

**PLEASE NOTE: This course outlines science teaching and learning for normally developing K–8 students. While the instructor will periodically make reference to specific accommodations for diverse learners, the onus is upon you as an emerging special educator to apply your expertise to the science teaching learned in this course.

Also, please note that this course focuses on ‘teaching science’ in elementary and middle grades, rather than teaching ‘science’ (content) itself. However, you will be given ample opportunity to learn and practice science content teaching through various assignments and activities during the course. **

Course Learning Outcomes:
Successful completion of this course will enable you to:

- Develop a rationale for the teaching of science to K–8 students;
- Draw upon theories of learning to plan appropriate science learning experiences;
- Learn to develop content knowledge and pedagogical knowledge as a means of teaching science to K–8 students;
  Use inquiry for students’ science learning in elementary/middle school;
- Plan and execute science lessons and activities in elementary/middle school classrooms;
• Make appropriate decisions in the assessment, management and organization of K–8 science classrooms;
• Feel comfortable, confident and enthusiastic about teaching science in elementary/middle school;

Course Required Reading:
• Ohio’s Academic Content Standards in Science (available online)
• Copies of various readings as provided in class or posted in BlackBoard.

Other Required Materials:
You will need to have a 4 GB USB to use to transfer your digital videos in order to conduct your microteaching reflections. You will also need teaching materials for the two microteaching presentations you will lead. See later sections for details.

Class Policies:
• Attendance Policy: Good attendance and punctuality are critical elements of teacher professionalism. In addition, because of the interactive nature of this course, regular attendance is required and expected.
  ❖ You are expected to attend and participate in every class. If an emergency arises, you must inform the instructor prior to the class meeting of your absence.
  ❖ You are expected to arrive on time and be well-prepared for every class meeting
  ❖ Absences—either excused or unexcused—and lateness could result in the lowering of your final grade.
  ❖ A lateness of more than 15 minutes or leaving class with 15 minutes or more than remaining will count as an absence.
  ❖ You are expected to actively engage in the learning experiences such as group and class discussions and communicate respectively with others in class.
• Late work will not be accepted without prior consent of the instructor. Late work equals a zero grade. If absent the day work is due in class, you must email your work to me by the starting time of class or it is considered late and will not be accepted.
• Reading assignments are to be completed before the class meeting for which they are assigned.
• Plagiarism is academic dishonesty and strictly prohibited. If you’re uncertain about plagiarism, it is your responsibility to ask for my assistance. Students who plagiarize will be reported and receive a grade of “0.” Plagiarism can also result in course failure. In cases of suspected plagiarism, university policy will be followed.
• No texting, net surfing, cell phone conversation allowed in class.
• If any student requires assistance or appropriate academic accommodations for a disability, please contact the SAS office immediately.
Assignment of Final Grades:
Final course grades will be determined according to the percentage of points students accumulate throughout the semester. The grading scale is presented below.

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>93%-100%</td>
<td>A</td>
</tr>
<tr>
<td>90%-92%</td>
<td>A-</td>
</tr>
<tr>
<td>85%-89%</td>
<td>B+</td>
</tr>
<tr>
<td>80%-84%</td>
<td>B</td>
</tr>
<tr>
<td>75%-79%</td>
<td>B-</td>
</tr>
<tr>
<td>70%-74%</td>
<td>C+</td>
</tr>
<tr>
<td>65%-69%</td>
<td>C</td>
</tr>
<tr>
<td>60%-64%</td>
<td>C-</td>
</tr>
<tr>
<td>55%-59%</td>
<td>D+</td>
</tr>
<tr>
<td>0%-54%</td>
<td>F</td>
</tr>
</tbody>
</table>

Important dates for course enrollment and withdrawal:
Last day to drop class without any effect on transcript—27th January 2013
Last day to withdraw class with “W” on transcript—24th March 2013

Assignment Overview (150 points)

1) Pre and Post questionnaires (total 5 points):
A pre-questionnaire will be given to you the first day of class. Please answer the questions in as much detail as possible. Post-questionnaires would be given toward end of the semester. These questionnaires help me to understand you better and modify the course as needed. These surveys won’t be ‘graded’ in the sense, the content of your answers won’t affect your grade. Every student who completes the pre AND post parts are automatically assigned 5 points.

2) Reading Reflection Cards (8 cards, 1.25 points each, 10 points total):
You will be given a reading assignment for almost every class session. Read, reflect and complete a reading card (typically a 5x7 index card). On the front, write your name, the date, reading # and a summary of the major points of the reading. On the back, reflect on what you read by noting (1) what surprised you? (2) what did you already know, and (3) what do you still have questions about?

3) Website Review (5 points):
You will be asked to find useful science educational websites and share them with your peers during a 5-minute time-slot during the semester. These websites could contain useful animations, simulations, lesson plans, graphics, etc. that can be used in class or for planning. Describe and navigate through the various useful features of the website. Email me the URL before your web review presentation. I will consolidate them to one list at the end of the semester for your future use.

4) Discrepant Event Microteaching Assignment (40 points):
Throughout the semester, you will be given the opportunity to teach twice in front of your peers. These short teaching assignments are also called microteaching. They are 20 mins long, and you will work in pairs/groups. Each microteaching assignment comes in 3 parts: a) you teach for 20 mins b) you submit a lesson plan on it and c) you submit a reflection
on your teaching experience. The first microteaching required you to use a discrepant event to teach a topic. Check following sections for details.

5) Inquiry Teaching Microteaching Assignment (40 points):
This is the second microteaching assignment. Here you will need to explicitly use inquiry. Check following sections for details.

6) Professional Conduct Assessment (10 points):
Students would be graded on elements of attendance and participation following the professional conduct rubric provided at the end of the syllabus. There is opportunity for self evaluation and peer evaluation by the instructor. Details would be announced on the day assigned for this assessment.

7) Midterm (20 points) and Final Exam (20 points):
Exams would include objective type questions as well as descriptive type questions. However, emphasis would be given on critical thinking and understanding and application of subject matter rather than memorizing content. More details would be provided by the instructor as needed.

8) Exit slips:
At the end of each class, you will be asked to fill out an exit slip that will help to get an idea how well (or poor) the class went. Writing your name is optional. Exit slips are not graded, but must be turned in at the end of each class period.

DISCREPANT EVENT (DE) TEACHING ASSIGNMENT (40 points)

The goal of this assignment is to perform content teaching in class USING A DISCREPANT EVENT ACTIVITY. You also write a lesson plan for it and reflect on your experience. This will be an introductory content teaching opportunity for many, and will focus on how creatively and effectively you teach. The assignment has three parts—a) submitting a lesson plan (guidelines provided) b) doing the teaching (also called microteaching) and c) writing a reflection paper on it. Completing of all three parts is mandatory.

What is a Discrepant Event? A discrepant scientific event is a surprising occurrence that challenges learners’ preconceptions. Often they at first appear to be nonacademic in nature and frequently differ from what is expected, thereby stirring the interest of students. Many fun activities in science fall into this category. These events generate a “Wow! How did this happen? Why did this happen?” in your students, engaging them to further learning. We will do several discrepant event activities in class before your microteaching—so that you get a sense of what they look like.
**Signing up:** You will work in pairs/groups. You will be given time to form your own group at the beginning of the semester. You may choose from the topic list provided or select something different (just make sure to let me know your topic one week in advance). Your group decides what grade level you choose to teach.

a) **DE Lesson Plan (20 points):** On the day you present, make sure you turn in your lesson plan. Format for the lesson plan is flexible, but you might want to follow the specified format as a guideline. (See attached template)

b) **DE Microteaching (10 points):** You will present the HANDS-ON portion of your lesson for 20 minutes to your class. This will NOT be enough time for you to get through the whole lesson. Instead, you will present the students with the main activity, let them work on it for a while, and then wrap up your presentation at 20 minutes. Feel free to use the computer, internet, handouts, activity sheets and materials as needed. On the day you present, make sure you turn in your lesson plan and a jump drive to take your video. Videos will be returned in your jump drives at the end of the class. This may be used while you write your reflection papers.

c) **DE Reflection paper (10 points):** Each microteaching experience will be digitally videotaped. You will have one week following the return of your USB containing your microteaching video to write your microteaching reflection. Some guiding questions may be:

1. What feedback did my peers give me about my teaching? What did I do well? What needs work?
2. From my viewing my video:
   a. How many questions did I ask? What kinds of questions did I ask?
   b. How effectively did I engage the students? How effectively did I communicate instructions?
   c. How effectively did I manage the class? To what extent did I have a “teacher presence?”
3. In what ways did I plan for and execute adaptations for different kinds of learners?
4. What would I do to improve this lesson and my teaching in general in the future? (provide specific action-able suggestions for the future).

**INQUIRY TEACHING ASSIGNMENT**

The goal of this assignment is to perform an INQUIRY-BASED teaching of a science lesson in your class. This will be an introductory science teaching opportunity USING INQUIRY. The assignment has three parts—a) submitting a lesson plan b) doing the teaching and c) writing a reflection paper on it. Completing of all three parts is mandatory.
Inquiry pedagogy is an important part of science instruction (NRC, 1996, 2012). According to *Inquiry and the National Science Education Standards*, there are 5 essential features of teaching by inquiry. These 5 essential features of inquiry include engaging in scientifically-oriented questions, giving priority to evidence, developing explanations from evidence, connecting explanations to scientific knowledge (extend), and communicating and justifying explanations. There are variations of the 5 essential features, and individual lessons may vary in the extent to which they represent “high” or “low” inquiry for the student. Your team will develop a guided inquiry lesson plan and present part of it to your class.

**Signing up:** You will work in groups and sign up for your inquiry microteaching at the beginning of the semester. You may choose from the *any* topic related to your academic interest. Let the instructor know your topic at the assigned date.

a) **Lesson Plan (20 points):** On the day you present, make sure you turn in your lesson plan. Format for the lesson plan is flexible, but you might want to follow the specified format as a guideline. (See grading rubric for template).

b) **Microteaching (10 points):** You will present the HANDS-ON portion of your lesson for 20 minutes to your class. This will NOT be enough time for you to get through the whole lesson. Instead, you will present the students with the activity, let them work on it for a while, and then wrap up your presentation at 20 minutes. Demonstrating your understanding of scientific inquiry in is key element of this assignment. Feel free to use the computer, internet, handouts, activity sheets and materials as needed. On the day you present, make sure you turn in your lesson plan and a jump drive to take your video. Videos will be returned in your jump drives at the end of the class. This may be used while you write your reflection papers. (See grading rubric for template).

c) **IT Reflection paper (10 points):** Each microteaching experience will be digitally videotaped. You will have one week following the return of your USB containing your microteaching video to write your microteaching reflection. Your microteaching reflection is an opportunity to address the following questions:

1) What level of inquiry did I use?
2) Comparing with my first teaching assignment, how well did this one go/did not go?
3) What would I do to improve this lesson and my teaching in general in the future? (provide specific action-able suggestions for the future)

**Recommended Lesson Plan Template (20 points)**

**Class (1)** Identify the class (grade level and/or subject area) for which the lesson is designed.
Topic (1) A clear, very brief topic describing the lesson.

Standards (2) Should identify all of the Ohio state standards which are covered by your lesson.

May include the Standard (e.g., “Life Sciences”), Benchmark (e.g., Benchmark A), and
Grade Level Indicator (write this out completely, see website for details).

Objectives (2) Explicitly describe what you want your students to learn. Objectives should be
very specific and represent the aims of your instruction and written
according to
class specifications and clear outcomes.

Materials (2) List all of the materials necessary for completing this lesson. You may wish to
identify items per students, items per group, or items per class.

Instructional Describe in detail what you plan to happen throughout the entire lesson. Most
Sequence (4) lessons can be divided into relatively discrete units of activity. You should
identify each of these units and describe what will take place. Generally, lessons include an ENGAGE portion, EXPLORE portion, EXPLAIN portion, and an ELABORATION portion, with EVALUATION opportunities embedded throughout.
Time: You should also estimate the time you think each of these units will take. Activities: Some of the titles you may choose to use for this section include anticipatory set, board work, student activity, demonstration, lecture, review, etc.
Guiding Questions: Include guiding questions you will use to guide students’ thinking. Any whole class instruction (lecture, etc.) should include some guiding questions. You may use Elstgeest (2001) as a guide.
Supporting Instructional Materials: Include a copy of the
PowerPoint/notes/handout with your lesson plan.

Assessment (2) Include a copy of ALL materials used to assess student learning (pre-tests, worksheets, Lab sheets, journal prompts, etc.)

Safety (2) Identify any safety concerns and precautionary measures taken to reduce risks. Include MSDS (found at ttp://www.flinsci.com/search_MSDS.asp) if using any chemicals.

Adapting Describe ways you will gear your lesson up and down for different
For Diverse students: students with disabilities, students who learn quickly, and Learners (2) students who learn less quickly or need more time/attention.

References (2) Cite any sources that you used in the preparation of this lesson. This should be a complete citation using APA format. Refer to Purdue OWL: (owl.english.purdue.edu/owl/resource/560/01/).

Scoring Rubric for Microteaching (10 pts)

<table>
<thead>
<tr>
<th>Group members:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Evidence of Planning</td>
<td>(Section Score: /2)</td>
</tr>
<tr>
<td>2. Instructional Organization and Development (Section Score: /2)</td>
<td></td>
</tr>
<tr>
<td>3. Presentation of Subject Matter (Section Score: /4)</td>
<td></td>
</tr>
<tr>
<td>4. Communication: Verbal and Nonverbal (Section Score: /2)</td>
<td></td>
</tr>
</tbody>
</table>

1. Evidence of Planning
- Demonstrates appropriate selection of materials/activities.
- Structures/sequences lessons in a manner leading to desired outcomes.
- Clearly has a sequence of guiding questions to drive the lesson.
- Plans for effective transitions, pacing, and time management.
- Overall is well organized.

2. Instructional Organization and Development
- Maintains momentum, keeps students on task.
- Effectively distributes materials.
- Provides feedback to students, responds, amplifies, and uses students’ ideas.
- Conducts beginning and ending review, summarizes, emphasizes important points, provides frequent guided practice.
- Facilities discussion between students.
- Involves many students.

3. Presentation of Subject Matter
- Formulates (operational) definitions in conjunction with students’ experiences.
- Provides examples, illustrations, and connections to everyday lives of students.
- Demonstrates mastery of science content, presenting subject matter accurately.
- Presents content using multiple modalities (e.g., tactile, visual, & auditory).
- Appropriate implementation of age-appropriate hands-on / minds-on activity.

4. Communication: Verbal and Nonverbal
- Can be heard by all students in room, even in the back (has a teacher presence)
- Gives clear directions, appropriate both for learners and task.
- Expresses enthusiasm and interest, motivates students.
- Uses signals and/or body language to maintain student attention.
- Effectively checks on students to maintain a productive classroom atmosphere.
- Moves around the class when appropriate.
**Additional Comments:**

**Assignment quick glance:**
Due to nature of the course, some of your assignment due dates will be different for different students depending on when you sign up for a particular task. The assignment quick reference should help know for sure which assignment is due when as the semester progresses. Make sure to fill out the “my date” sections on the first day before you leave class. Talk to your instructor if you need assistance.

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Points</th>
<th>Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre and Post Questionnaires</td>
<td>5</td>
<td>1/16 and 5/1</td>
</tr>
<tr>
<td>10 Reading Cards (1 pt each)</td>
<td>10</td>
<td>Throughout Semester</td>
</tr>
<tr>
<td>Website Review</td>
<td>5</td>
<td>Your Date:</td>
</tr>
<tr>
<td>Discrepant Event (DE) Microteaching</td>
<td>10</td>
<td>Your Date:</td>
</tr>
<tr>
<td>Submitting Lesson Plan for DE</td>
<td>20</td>
<td>* Same as above</td>
</tr>
<tr>
<td>Submitting Reflection for DE</td>
<td>10</td>
<td>1 week after DE</td>
</tr>
<tr>
<td>Inquiry Teaching (IT) Microteaching</td>
<td>10</td>
<td>Your Date—</td>
</tr>
<tr>
<td>Submitting Lesson Plan for IT</td>
<td>20</td>
<td>** Same as above</td>
</tr>
<tr>
<td>Submitting Reflection for IT</td>
<td>10</td>
<td>1 week after IT</td>
</tr>
<tr>
<td>Midterm</td>
<td>20</td>
<td>2/26</td>
</tr>
<tr>
<td>Final</td>
<td>20</td>
<td>5/8</td>
</tr>
<tr>
<td>Professional Conduct</td>
<td>10</td>
<td>TBA</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

**Grading**
Final course grades will be determined according to the percentage of points students accumulate throughout the semester. The grading scale is presented below.

<table>
<thead>
<tr>
<th>Percentage Range</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>93%-100%</td>
<td>A</td>
</tr>
<tr>
<td>90%-92%</td>
<td>A-</td>
</tr>
<tr>
<td>85%-89%</td>
<td>B+</td>
</tr>
<tr>
<td>80%-84%</td>
<td>B</td>
</tr>
<tr>
<td>75%-79%</td>
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</tr>
<tr>
<td>70%-74%</td>
<td>C+</td>
</tr>
<tr>
<td>65%-69%</td>
<td>C</td>
</tr>
<tr>
<td>60%-64%</td>
<td>C-</td>
</tr>
<tr>
<td>55%-59%</td>
<td>D+</td>
</tr>
<tr>
<td>0%-54%</td>
<td>F</td>
</tr>
</tbody>
</table>
# Professional Conduct Rubric (10 pts)

<table>
<thead>
<tr>
<th>Standard</th>
<th>Outstanding Performance</th>
<th>Good Performance</th>
<th>Marginal Performance</th>
<th>Unsatisfactory Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class Activities</strong></td>
<td>Participated in class activities, simulations, and labs in every class always taking an active/leadership role in activities.</td>
<td>Participated in class activities, simulations, and labs in every class usually taking an active/leadership role in activities.</td>
<td>Participated in class activities, simulations, and labs in every class, but typically just followed along without assuming an active/leadership role in activities.</td>
<td>Participated in most class activities, simulations, and labs hardly ever assuming an active/leadership role in activities.</td>
</tr>
<tr>
<td><strong>Readings</strong></td>
<td>Completed all assigned readings on time.</td>
<td>Completed all assigned readings.</td>
<td>Completed most of the assigned readings.</td>
<td>Completed some of the assigned readings.</td>
</tr>
<tr>
<td><strong>Class Discussion</strong></td>
<td>Answered questions and consistently contributed to class discussions in every class.</td>
<td>Answered questions and consistently contributed to class discussions in most classes.</td>
<td>Occasionally answered questions and contributed to some class discussions.</td>
<td>Did not participate in class discussion very often.</td>
</tr>
<tr>
<td><strong>Student Presentations</strong></td>
<td>Listened attentively to all student presentations and always completed assigned roles and tasks.</td>
<td>Listened attentively to all student presentations and usually completed assigned roles and tasks.</td>
<td>Listened attentively to most student presentations.</td>
<td>Frequently did not pay attention during student presentations.</td>
</tr>
<tr>
<td><strong>Small Groups</strong></td>
<td>Contributed to small group discussions/assignments and encouraged others to participate in group activities in every class.</td>
<td>Contributed to small group discussions/assignments in every class.</td>
<td>Contributed to small group discussions/assignments in most classes.</td>
<td>Frequently did not contribute to small group discussions/assignments.</td>
</tr>
<tr>
<td><strong>Preparation</strong></td>
<td>Always prepared for class: finished readings &amp; assignments on time; prepared for presentations &amp; discussions.</td>
<td>Usually prepared for class: finished readings &amp; assignments on time; prepared for presentations &amp; discussions.</td>
<td>Sometimes prepared for class: finished readings &amp; assignments on time; prepared for presentations &amp; discussions.</td>
<td>Frequently unprepared for class.</td>
</tr>
<tr>
<td><strong>Attendance</strong></td>
<td>No absences, never late to class</td>
<td>1 absence or late to class occasionally</td>
<td>2-3 absences/late to class</td>
<td>4 or more absences/late to class.</td>
</tr>
<tr>
<td><strong>Disposition</strong></td>
<td>Always conveyed positive attitude toward class &amp; assignments; approached conflicts constructively</td>
<td>Usually conveyed positive attitude toward class &amp; assignments; approached conflicts constructively</td>
<td>Sometimes conveyed positive attitude toward class &amp; assignments; approached conflicts constructively</td>
<td>Complained frequently, did not approach conflicts constructively.</td>
</tr>
</tbody>
</table>
### C&I 47502/57502  Spring 2014 (Section 001)—Tentative Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Content/Pedagogy</th>
<th>Assignments due</th>
<th>Who’s presenting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/16</td>
<td>Introductions, Nature of Science</td>
<td>Prequestionnaires (2.5)</td>
<td>Sign up for DE, IQ, web</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Recreating Fossils, Mystery Tube</td>
<td>assignments</td>
</tr>
<tr>
<td>2</td>
<td>1/23</td>
<td>Inquiry</td>
<td>Reading Card 1</td>
<td>W1, W2, W3</td>
</tr>
<tr>
<td>3</td>
<td>1/30</td>
<td>Conceptual Change</td>
<td>Reading Card 2</td>
<td>W4, W5, W6</td>
</tr>
<tr>
<td>4</td>
<td>2/6</td>
<td>Learning Cycle</td>
<td>Reading Card 3</td>
<td>W7, W8, W9</td>
</tr>
<tr>
<td>5</td>
<td>2/13</td>
<td>Safety</td>
<td>Reading Card 4</td>
<td>W10, W11, W12</td>
</tr>
<tr>
<td>6</td>
<td>2/20</td>
<td>Science Standards</td>
<td>Reading Card 5</td>
<td>W13, W14, W15</td>
</tr>
<tr>
<td>7</td>
<td>2/27</td>
<td>Midterm</td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>3/6</td>
<td>Converting Cookbook Labs</td>
<td>Reading Card 6</td>
<td>W16, W17, W18</td>
</tr>
<tr>
<td>9</td>
<td>3/13</td>
<td>DE Microteaching—day 1</td>
<td>Lesson Plans from day 1 presenters</td>
<td>DE day 1 presenters</td>
</tr>
<tr>
<td>10</td>
<td>3/20</td>
<td>DE Microteaching—day 2</td>
<td>Reflections from day 1 presenters,</td>
<td>DE day 2 presenters</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Lesson Plans from day 2 presenters.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>3/27</td>
<td>No Class</td>
<td></td>
<td>SPRING BREAK</td>
</tr>
<tr>
<td>12</td>
<td>4/3</td>
<td>Creative Assessment</td>
<td>Reflections from day 2 presenters,</td>
<td>W19, W20, W21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reading Card 7</td>
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<tr>
<td>13</td>
<td>4/10</td>
<td>Adaptation for Diverse Learners</td>
<td>Reading Card 8</td>
<td>W22, W23, W24</td>
</tr>
<tr>
<td>14</td>
<td>4/17</td>
<td>INQUIRY Microteaching—day 1</td>
<td>Lesson Plans from day 1 presenters</td>
<td>IQ day 1 presenters</td>
</tr>
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<tr>
<td>15</td>
<td>4/24</td>
<td>INQUIRY Microteaching—day 2</td>
<td>Reflections from day 1 presenters,</td>
<td>IQ day 2 presenters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lesson Plans from day 2 presenters.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>5/8</td>
<td>FINAL EXAM</td>
<td>Reflections from day 2 presenters</td>
<td></td>
</tr>
</tbody>
</table>

*Note: This schedule is tentative and may be modified with notification as the semester progresses.*
Disposition Statement

A major part of our teacher education program at Kent State University is the Development of dispositions related to as caring, fairness, honesty, responsibility, commitment, and social justice. To assess the development of these dispositions, an assessment will be administered by a faculty member or field-based supervisor no later than the last week of this class (ninth week if a needs improvement is to be assigned). A candidate will find a sample of the assessment at [www.ehhs.kent.edu/stuportal](http://www.ehhs.kent.edu/stuportal). Candidates are expected to consistently demonstrate all of the behaviors and qualities indicative of professionalism, work ethic, and personal qualities in order to receive a grade of Satisfactory for Student Teaching. At any time during a candidate’s program, a faculty member or field-based supervisor with concerns may complete the disposition assessment. If a candidate is directed to complete a disposition plan (PDP) for an area rated as needs improvement, it is the candidate’s responsibility to go to the student portal at [www.ehhs.kent.edu/stuportal](http://www.ehhs.kent.edu/stuportal), complete the professional disposition plan, arrange a meeting with the faculty member who assigned the needs improvement, electronically sign the PDP and live up to the terms of the agreement within the time specified. At the end of designated time period it is the candidate’s responsibility to arrange a meeting with the faculty to provide evidence that the terms outlined in the PDP have been met. The faculty member will then initiate a Follow-up PDP found at the faculty staff portal. This follow-up PDP needs to be electronically signed by the candidate at the student portal before it will be considered completed. If a needs improvement is assigned after the 9th week of a course, the coordinator may be involved to monitor progress of completion of the PDP into the subsequent semester. Failure to improve in the area rated as Needs Improvement and failure to follow the process outlined above may result in removal from the teacher education program at any time.
Appendix B

Interview Protocol

1. Background information from participants
   a. Tell me a little bit about your academic background. Where you are in the program?
   b. What are some courses you have taken?
   c. Did you have any field experiences?
   d. Have you got any prior teaching experience?
   e. What science courses have you taken so far?
   f. Have you taken any classes with a lab?

2. How participants define and characterize inquiry
   a. We have talked a lot about scientific inquiry. If you had to explain it to someone who didn’t know what it was, how would you define scientific inquiry?
   b. Do you remember what some key features of inquiry are?
   c. How these features may work with your students in special education?
   d. Out of the different features of inquiry, which one do you feel is most important for your students? Why do you think so? (What about special needs students? Why do you think so?)
   e. So, what do you think of teaching with scientific inquiry? For all students or special needs students?
   f. Thinking about students in your area of special education specialization. Do you think inquiry-based science teaching would work for this group? Why? Tell me why you think that?
   g. What are some factors that one needs to keep in mind while teaching science to special needs students using inquiry?
   h. What role does a teacher play in an inquiry-based classroom with special needs students?
3. Views on their own inquiry-based teaching experience (Inquiry Microteaching)

a. Let’s switch to your own inquiry-based teaching in this class. We are talking about microteaching experience. Remind me what you did in your inquiry-based microteaching assignment.

b. How well did it go? Why do you think so?

c. In thinking about it now, did your microteaching demonstrate the presence inquiry? How so? What features were present?

d. Do you think the learning objectives for your lesson were accomplished using inquiry?

e. Do you remember the four level of inquiry?—What level of inquiry do you think you taught with?

f. What makes you think you that your lesson was at that level?

g. Why did you choose this level?

h. Let’s focus on some specific inquiry-based tasks that you used during your inquiry microteaching. Remind me some inquiry-based tasks you did during your inquiry-based microteaching.

i. Thinking about various inquiry-based tasks—do you think these tasks will be useful to your special needs students? How so?

j. What was your role in that inquiry-based classroom? As a teacher, what are some things you did to support your student’s learning?

k. For you, which teaching experience (between DE Microteaching and II) was better and why?

l. Do you think this microteaching experience will have in effect in your future science teaching? Why?

4. Views on science methods course

a. What are some topics that you found most useful in this course? (Refer to the ones the mentioned in POST-Q). Can you please explain?
b. What are some assignments that you found most useful in this course? (Like the microteaching, reflection writing, reading cards, etc.). Can you please explain some of your views on this?

c. Do you think this type of science methods course will have in effect in your future science teaching? Why?

5. Inquiry in special education context

a. Summarize for me please—Do you think inquiry-based science teaching is important for your students in special education? Why or why not?

b. Do you think inquiry-based science teaching is important for your special needs students or all students in general? Why or why not?

c. How might special education teachers use inquiry with their students in special education?

d. Which special needs students do you think would benefit most from inquiry-based teaching? (Mild-Mod, Mod-Intense, ED, Hearing challenged, any other special need group)? How so?

e. Good. You have identified the benefits of inquiry with special education learners. What about some challenges? Do you see any potential concerns in practicing inquiry with these special education groups? Please explain.

6. Future plans for using scientific inquiry

a. Let’s talk about your future science teaching. In your ideal teaching assignment,

   i. What grades would you like to teach?

   ii. In what setting?

b. In your ideal teaching assignment, describe a typical day in your science teaching class? Does this include your students in special education?

c. Would you like to use inquiry in your future science classroom? How so? What features will you use?

d. What are some inquiry-based tasks that you might use with your students in special education?
e. How would you use inquiry to teach your future students in special education using inquiry?

f. How much time in a class day or period do you imagine you are likely to engage students in scientific inquiry?

g. How well prepared do you feel right now for teaching science to your future students using inquiry? What about science teaching in general?

h. What are some concerns you still have with inquiry? What about science teaching in general? Do you have any plans to address this concern?

i. OPTIONAL QUESTION—I see a transition in your preparedness in teaching science. Can you explain this?

7. Other questions—earlier learning experience about scientific inquiry

a. Do you remember when and where did you first learn about scientific inquiry? (When and where?)

b. Did you have any experience prior to this class? Were any of your K–12 classes inquiry-based?

c. Have any other education classes dealt with inquiry? special education courses?

d. How did you feel when we first started doing inquiry in our class? Did this feeling change over the course? How so?
APPENDIX C

QUESTIONNAIRE PROTOCOL
Appendix C

Questionnaire Protocol

Pre-questionnaire Protocol

1. How has been your science learning experience so far? Positive, negative or neutral? Please explain your response.
2. How well prepared do you feel right now for teaching science to your future students?
3. As a special education major, how important do you think science teaching will be for your future job? Why so?
4. As a special education major, what do you see as the biggest challenge that you will face if you teach science in the future?
5. Have you heard about Inquiry or Scientific Inquiry? Please describe your response.
6. Have you heard about the Science Education Standards? (Yes/No).

Post-questionnaire Protocol

1. Do you think this course would make your own science learning experiences as positive, neutral, or negative so far? Please explain.
2. After taking this course, how well prepared do you feel right now for teaching science to your future students?
3. After taking this course, how important do you think science teaching will be for your future job?
4. After taking this course, what do you see as the biggest challenge that you will face if you teach science in the future?
5. How did this course change your ideas about teaching science? (Up to three changes please)
6. Which area of pedagogy learnt in this class, you liked the most and want to apply to your teaching? (Choose all that apply)
   a. Nature of Science
   b. Conceptual change
   c. Inquiry
d. Modifying Cookbook labs
e. Standards
f. Creative assessment
g. Adapting lessons for diverse learners
h. Other: Please specify: ____________________________________________

7. Is it ok if we contact you in the future for future course improvement/ recommendations?
   a. Yes
   b. No
APPENDIX D

FINAL CODE TABLES
Appendix D

Final Code Tables

**Final Code Table for Research Question 1: Preservice Special Education Teachers’ Definitions and Characterizations of Inquiry**

<table>
<thead>
<tr>
<th>Final Codes</th>
<th>Range</th>
<th>Exemplars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding what inquiry was NOT</td>
<td>Student-driven</td>
<td>“It is kind of student driven, and kind of giving a lot of the responsibilities to the students and not telling them what to do.” Carol, interview.</td>
</tr>
<tr>
<td>Understanding what inquiry instruction was NOT</td>
<td>Not talking at students</td>
<td>“It is guiding them through instead of talking at them.” Emily, interview.</td>
</tr>
<tr>
<td></td>
<td>Not lecturing</td>
<td>“It is not lecturing.” Luke, interview.</td>
</tr>
<tr>
<td></td>
<td>Not just teaching content</td>
<td>I would say—teaching in a manner that provokes thought …as opposed to a book definition of the topic you’re trying to teach.” Mike, interview.</td>
</tr>
<tr>
<td></td>
<td>Not entirely teacher-directed</td>
<td>“I would say it is an approach to teach science which is not entirely teacher-directed.” Gail, interview.</td>
</tr>
<tr>
<td>Overlap in understanding inquiry and inquiry instruction</td>
<td>Inquiry as teaching method</td>
<td>“It is a teaching method.” Olivia, interview.</td>
</tr>
<tr>
<td></td>
<td>Overlap in students and teachers role</td>
<td>“I would tell them that it is more of like questions and discovery based as opposed to lecturing about.” Francine, interview.</td>
</tr>
<tr>
<td></td>
<td>Inquiry as “5Es”</td>
<td>“It’s the five E’s…Questioning, evidence, explaining, and the extensions and then the evaluations.” Brian, interview.</td>
</tr>
<tr>
<td>Match with NRC’s version</td>
<td>Inquiry as a learning method</td>
<td>“Inquiry is a learning method based on questioning.” Brian, interview.</td>
</tr>
<tr>
<td></td>
<td>Students answer questions by data collection and analysis</td>
<td>“It was asking questions to the students so that they can lead to their own experiences and manipulate things and come up with their own questions and things like that.” Kim, interview.</td>
</tr>
<tr>
<td>Mismatch with NRC’s version</td>
<td>Extend as providing depth.</td>
<td>“Like you want to take something and extend it. You want to pull it out to really good detail with it and inquiry just does that automatically.” Emily, interview.</td>
</tr>
<tr>
<td></td>
<td>Questions as pre-assessment tool</td>
<td>“Asking questions, giving questions, recalling their prior knowledge through these.” Brian, interview.</td>
</tr>
</tbody>
</table>
### Final Code Table for Research Question 2—Preservice Special Education Teachers’ Enactment of Inquiry Instruction

<table>
<thead>
<tr>
<th>Final Codes</th>
<th>Description/Range</th>
<th>Exemplars</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Asked at least one scientifically-oriented question to initiate investigation</strong></td>
<td>Participants asked one question that prompted students’ data collection and analysis</td>
<td>All groups. Example from first group: “If the bucket represents all the water on earth’s surface, how much water do you think is drinkable?” (Inquiry Microteaching video, Brian and Paula)</td>
</tr>
<tr>
<td><strong>Students were given collected data</strong></td>
<td>Students collected data</td>
<td>All groups. Example from first group: Students predicted amounts of water present in different sources of water on earth and measured their predictions using cups, spoons and droppers.</td>
</tr>
<tr>
<td><strong>Teachers explained findings following explorations</strong></td>
<td>Teachers debriefed science content behind activity instead of allowing students to develop their own results.</td>
<td>All groups. Example from first group: “Alright, let’s see the actual amounts. Let’s begin with oceans. So what percentage did you for oceans? 70? 90? 81? Well you are right. Ocean makes 97% of earth’s water.” (Brian, inquiry microteaching video 20:00)</td>
</tr>
<tr>
<td><strong>Teachers connected findings to development of scientific knowledge</strong></td>
<td>Teachers connected findings of the activity to scientific knowledge</td>
<td>All groups. Example from first group: “I want you to understand that only 0.0003 % of water is available for human consumption.” (Brian, inquiry microteaching video 20:20)</td>
</tr>
<tr>
<td><strong>Teachers communicated and justified results</strong></td>
<td>Teachers communicated and justified activity toward scientific knowledge</td>
<td>All groups. Example from first group: “So you see, less than 1% of earth’s water is drinkable.” (Brian, inquiry microteaching video 22:00)</td>
</tr>
<tr>
<td><strong>Level of inquiry</strong></td>
<td>Structured inquiry: T asked questions, gave procedures and provided solutions</td>
<td>All groups except Jack and Mike’s group (inquiry microteaching videos)</td>
</tr>
<tr>
<td></td>
<td>Guided inquiry: T asked questions, students developed procedures and solutions</td>
<td>Jack and Mike’s group (inquiry microteaching videos)</td>
</tr>
<tr>
<td><strong>Disconnect between interpreting the levels of inquiry</strong></td>
<td>Participants’ classification not matching my classification.</td>
<td>“So we didn’t give them the instructions either. We let them figure it out on their own.” (Kim, interview) versus giving students step-by-step directions during teaching (as observed in their teaching video)</td>
</tr>
<tr>
<td>Nominal adaptation for diverse learners</td>
<td>Only in lesson plan, not in teaching</td>
<td>Brian and Paula (no mention of adaptation in video)</td>
</tr>
<tr>
<td>----------------------------------------</td>
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<tr>
<td>Addressed both in lesson plan and during actual teaching</td>
<td>“Gear down the lesson using pictures with descriptions for lower level students.” Francine, inquiry lesson plan.</td>
<td>“The jeopardy Game questions vary in difficulty, allowing for differentiation while playing the game.” Adam and Gail.</td>
</tr>
<tr>
<td>Final Codes</td>
<td>Description/Range</td>
<td>Exemplars</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Inquiry supports science learning in all students, including students with disabilities</td>
<td>Participants articulate that inquiry instruction supports all learners, including learners with disabilities.</td>
<td>“It works for all students.” Kim, interview.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“It’s not just for special needs students. It can help any student.” Carol, interview.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“I think it makes sense to both kinds of students. It makes sense for both typical learners and atypical learners.” Brian, interview.</td>
</tr>
<tr>
<td></td>
<td>Support students with disabilities</td>
<td>“A lot of students with um with special needs have a lot of sensory needs. So being able to pick things up and feel them in their hands and get the feel for what the item is or what—what texture is—is something. Really—it can almost be therapeutic for students. Definitely a great way to teach special education.” Mike, interview.</td>
</tr>
<tr>
<td>Inquiry may be difficult with some students</td>
<td>Difficult with learners with disabilities</td>
<td>“I think a lot of times our students have a shorter attention spans, or limited cognitive skills. So it is keeping them on track—the part that is open may be [difficult].” Brian, interview.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“Like a lot of Behavioral issues. You don’t want them to do this. You have to perhaps be little careful with what you are doing”. Jack, interview.</td>
</tr>
<tr>
<td>Inquiry can be adapted to fit diverse learners’ needs</td>
<td>Participants articulate that inquiry lesson can be modified to fit students in special education’ needs.</td>
<td>“It is just that [inquiry] may be tailored differently. It might be bumped down and bumped up depending on the level of your students and the accommodations they have.” Brian, interview.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“I think it can work in any context as long as you modify it.” Carol, interview.</td>
</tr>
<tr>
<td>Knowledge of students’ needs and levels was important while doing inquiry</td>
<td>Participants articulate that knowledge of their special education learners was needed to do inquiry</td>
<td>“Yeah, well adapting is obviously important.” Adam, interview.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“You have to take into consideration each learner…I mean knowing your students and then modifying accordingly.” Brian, interview.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“I think knowing their needs is so important. Like being able to differentiate a lesson, being able to—whether it is content or whether they need to be assessed in a different way to explain their understanding.” Gail, interview.</td>
</tr>
<tr>
<td>Views on Questioning</td>
<td>Support all learners</td>
<td>Support students with disabilities</td>
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<tr>
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</tr>
<tr>
<td>“I think the main thing I got about inquiry was that it was asking questions to the students so that they can lead to their own experiences and manipulate things and come up with their own questions and things like that.”</td>
<td>Kim, interview.</td>
<td>“Let’s say you are teaching about temperature and the sun, some from the special education perspective can be—is the sun hot or is it cold? Questions that get you to where you want to go.”</td>
</tr>
<tr>
<td>“I think it can work in any context as long as you modify it... Like some ideas for questions. Like when I see that they can’t generate their own questions, I suggest some.”</td>
<td>Carol, interview.</td>
<td>“There are a lot of phrasing issues—like being very specific with your questioning.”</td>
</tr>
<tr>
<td>“Not too many to overwhelm them but enough so that it will guide them into their own.”</td>
<td>Nancy, interview.</td>
<td>“A lot of times it is hands-on in nature, so it gets students involved, it gets excited about what they are doing.”</td>
</tr>
<tr>
<td>“Hands on experiences and letting students know, leading to their own questions, letting them explore helps them to connect better to their topic,”</td>
<td>Kim, interview.</td>
<td>“And you can apply [hands-on experiences] to any aspect of special education.”</td>
</tr>
<tr>
<td>“A lot of the students are more tactile. So hands on works really well for them. But if you have a visual or auditory challenged student, then you might want to make some accommodations.”</td>
<td>Jack, interview.</td>
<td>“A lot of the students are more tactile. So hands on works really well for them. But if you have a visual or auditory challenged student, then you might want to make some accommodations.”</td>
</tr>
<tr>
<td>“You have to be careful of what type of students you are dealing with.”</td>
<td>Jack, interview.</td>
<td>“You have to be careful of what type of students you are dealing with.”</td>
</tr>
<tr>
<td>“The more examples they are able to see, the more they can connect to the topic and understand it.”</td>
<td>Kim, interview.</td>
<td>“The more examples they are able to see, the more they can connect to the topic and understand it.”</td>
</tr>
<tr>
<td>“And then the extension is huge. It’s like—you know life examples and things that people can relate to.”</td>
<td>Holly, interview.</td>
<td>“And then the extension is huge. It’s like—you know life examples and things that people can relate to.”</td>
</tr>
<tr>
<td>“You would try to extend their knowledge—see if they can apply this knowledge elsewhere.”</td>
<td>Olivia, interview.</td>
<td>“You would try to extend their knowledge—see if they can apply this knowledge elsewhere.”</td>
</tr>
</tbody>
</table>
| “Probably the extend-and-apply-to-other-situations is important. Because a lot of students in special education is focused on generalizing their knowledge and their skills. So it’s like—you couldn’t get off the example of the water freezing.” | }
That’s a very basic concept.” Francine, interview.

“Looking at evidence would be a big thing for these kids because they can concretely be able to see things that would help them in their learning.” Emily, interview.

“Like when you are having them to look for evidence, you probably also have to give them like one or two steps—like how to get there.” Debra, interview.

“The figuring-out-why part is important [sic].” Olivia, interview.

“Having to be able to justify that later. Having to go forward and justifying something.” Gail, interview.

“The only thing probably is—it’s hard for me to bridge the extending to justifying and communicating perhaps. Like a lot of time extension take—they kind of go towards different veins of thought. And then you have to get back to your original vein of thought with the justifying.” Brian, interview.

“Like these students may not be capable of doing all these. So with an IQ of 26, will they be able to communicate and justify effectively.” Jack, interview.

“There is probably like a level of students that I have worked with that need that more structured, more specific instructions. If you don’t give them procedures, especially when there is a lot going on like right now, you are going to get something really kind of crazy.” Gail, interview.

“Like with moderate to intense kids, you would have to take the content that you want to teach, take the specific things and throw in the inquiry”. Emily, interview.

“It seems from my experience that structure is a good thing in any special education classroom.” Brian, interview.

“It’s transcendental in nature, it can work with any student, any subject. I mean it is cross categorical. I mean it is not like it can be applied to only science and math. You can do this with every lesson.” Brian, interview.

“Not just in science but in life. We can do it in Math, in Social Studies.” Jack, interview.

“I feel like I did not have many teachers who asked questions. And a lot of them were just cookbook labs.” Carol, interview.

“I really struggled with science in my grade school. And I feel like if my teacher or my classroom was bit more inquiry-based, I think it would have helped me a lot to learn more.” Emily,
Views arise from own learning styles
Participants as learners preferred learning by inquiry

“I know that I don’t learn best through lectures. I know I learn best with hands on experiences.” Kim, interview.

“I mean if you are talking at me, I am not just going to learn it. But if I am going to learn if I find out why it happened that way, or make that happen and observe and understand. I am like more of a hands-on learner. I just can’t be like told things.” Francine, interview.

First experience with inquiry
Participants articulate that this class was first experience with inquiry

“This class. I have never even heard about it before this class.” Kim, interview.

“I feel like the first time I heard about “scientific inquiry” was your class. I have heard scientific method, that’s the only think that I really remember hearing about.” Carol, interview.
### Final Code Table for Research Question 4: Preservice Special Education Teachers’ Future Plans of Using Inquiry Instruction

<table>
<thead>
<tr>
<th>Final Code</th>
<th>Description/Range</th>
<th>Exemplars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intent to incorporate inquiry</td>
<td>Participants articulate whether they are willing to incorporate inquiry in their future classrooms</td>
<td>“I am definitely going do it.” Brian, interview.</td>
</tr>
<tr>
<td>Perception of inquiry as useful pedagogical tool</td>
<td>Participants articulate why they were willing to incorporate it in their future classrooms</td>
<td>“I would [use it]. I like this inquiry too because you can interact so much with the students and not just up there talking the whole time.” Ida, interview.</td>
</tr>
<tr>
<td>Envisioning inquiry in diverse instructional setting</td>
<td>Participants describe their future role</td>
<td>Co-teacher in an inclusive classroom: “If I would have to pick, I would rather pick a co-teaching experience.” Olivia, interview.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>special education resource room: “I see myself in a self-contained classroom.” Nancy, interview.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed setting: “I mean I honestly would like to do a little of everything.” Mike, interview.</td>
</tr>
<tr>
<td>Insufficient content knowledge a concern</td>
<td>Participants articulate that their lack of content knowledge to be a potential concern to their future science teaching.</td>
<td>“I’m comfortable [with inquiry]. It’s just the content and all the subjects. I feel like this has always been one of my main worries, especially being a special education teacher.” Carol, interview.</td>
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<td>“It’s the content that scares me the most.” Emily, interview.</td>
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<td>Time and resources as concerns with future plans of inquiry</td>
<td>Participants articulate that their lack of time and resources to be a potential concern to their future science teaching.</td>
<td>“We don’t know if every time if we can afford these five or ten sets of every experiment.” Francine, interview.</td>
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<td>“The time and resources.” Adam, interview.</td>
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<td>Lack of science teaching opportunity a concern with future plans of inquiry</td>
<td>Participants articulate a lack science teaching opportunity to be a potential concern.</td>
<td>“I don’t know if I will actually get to like teach a subject, because right now what I feel is that I would be more likely to be teaching reading and math because it is those the ones that are now really focused on.” Francine, interview.</td>
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<td>“But I wouldn’t be able to science teach because I’m not highly qualified in science.” Holly, interview.</td>
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REFERENCES


