PRESERVICE ELEMENTARY TEACHERS' PERCEPTIONS OF THEIR UNDERSTANDING OF SCIENTIFIC INQUIRY-BASED PEDAGOGY AND THEIR CONFIDENCE TO TEACH SCIENCE: INFLUENCE OF ELEMENTARY SCIENCE EDUCATION METHODS COURSE AND SCIENCE FIELD EXPERIENCE

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By

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ABSTRACT

The purpose of this research was to determine from elementary preservice teachers' perspectives their understanding of inquiry-based pedagogy and their confidence to teach science after concurrently completing a traditional elementary science education methods course and the associated science field experience. Results of this study indicate that when multiple inquiry-based experiences and instructional strategies, consistent with the National Science Education Standards, are integrated into a traditional elementary science methods course and reinforced through observations of classroom practice in the field, preservice teachers develop an understanding of scientific inquiry and inquiry-based science instruction, develop an appreciation for the benefits of teaching and learning science in a constructivist environment, develop confidence to teach science and indicate intent to use inquiry-based science teaching strategies in their own classroom practice. Findings from this research study have implications for the design of the elementary education science methods course and its associated science field experience.

CHAPTER ONE

Introduction

The National Science Teachers' Association (NSTA) surveys found in literature indicate serious deficiencies in the science preparation of elementary teachers (Weiss et al., 2001; 2003; Wilson et al., 2001; NSTA, 1998). The *National Assessment of Educational Progress (NAEP): Report Card for the Nation and States* (O'Sullivan, Reese, & Mazzeo, 1997) indicates that preservice teachers do not have a clear understanding of the teaching of science. Research also indicates that students K-12 possess inadequate understanding of scientific inquiry (Lederman, 1998). To achieve knowledge and understanding about science, the National Science Education Standards (NSES) emphasize teaching and learning science through inquiry (NRC, 1996).

Literature indicates that scientific inquiry complements science instruction and that the inquiry form of science instruction can be used to teach students the concepts and processes of the nature of science (Bianchini & Colburn, 2000). It has been proposed that teachers who lack a functional and conceptual understanding of scientific inquiry would not be able to teach science in a constructivist environment recommended by the NSES (Lederman, 1998). The NSES define scientific inquiry as the "diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work" (NRC, 1996. p. 23). Lederman (1998) defines scientific inquiry as the science process that utilizes scientific knowledge, reasoning and critical thinking to conduct investigations resulting in the development of scientific knowledge.

Contemporary reform efforts in science education emphasize the importance of children learning science through inquiry (American Association for the Advancement of

Science (AAAS), 1990; 1992; 1993; National Research Council (NRC) 1996; 2000). Science educators in the United States have long recommended that teaching science as inquiry should be a priority in science education and that inquiry be placed at the core of science instruction (DeBoer, 1991; DeBoer & Bybee, 1995; Lawson, 1995; Tamir, 1983). Science education research on inquiry related experiences of teachers (Abell, 2000; Crawford, 2000; Simpson, 2000), inquiry related experiences of students (Lehrer et al., 2000; Wild, 2000) and classroom inquiry (Anderson, 2002) support inquiry-based science instruction. Inquiry has been used to describe a method of science instruction (Chiappetta, 1997; DeBoer, 1991; NRC, 1996; Schwab, 1962; Tamir, 1983). Instruction using inquiry is believed to develop students' science process skills, promote their understanding of science content, scientific inquiry, and science (NRC, 1996). Therefore, understanding inquiry and exposure to inquiry-based pedagogies is important for the training of prospective elementary teachers.

National Science Education Standards

One of the major outcomes of the national science education reform efforts was the promulgation of the National Science Education Standards (NSES). These standards advocate a constructivist approach to teaching and learning where science is learned through exploring and discovery (NRC, 1996; 2000). Inquiry in the NSES is defined as "a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results" (NRC, 1996 p.23). Inquiry, is also described as the “activities of students in which they develop knowledge and understanding of scientific ideas, as well as understanding of how scientists study the natural world” (NRC, 1996, p.23).

The NSES vision for science education is scientific literacy for all students. Scientific literacy in the NSES document, includes both the abilities required to do science and the understanding of what science is, what science is not, what science can and cannot do, and how science contributes to culture (NRC, 1996). For students to grasp these concepts the NSES recommend that teachers use inquiry-based science pedagogies to teach science as these instructional strategies engage students in constructing and learning from their experiences. This is based on the premise that student understanding of science is actively constructed through individual and social processes. However, the NSES document does not operationally define inquiry-based teaching; instead the NSES provide guidance on what science students should know, how teachers should teach science, and how teachers should assess students (Abd-El-Khalick, 2004; Anderson, 2002).

According to the NSES students’ inquiry-based experiences should develop their abilities to conduct inquiry, their critical thinking abilities, their scientific reasoning and a deeper understanding of science (NRC, 2000). Thus, the goal of the NSES is three fold, one to develop students’ abilities to do inquiry, second to help students understand science content and third to help students understand the nature or concepts of scientific inquiry (NRC, 2000). To develop fundamental abilities required to do inquiry as recommended by the NSES, teachers of science must provide multi investigational opportunities for their students (Barrow, 2006).

Inquiry in the NSE standards is addressed both in the content standards for science as inquiry and in the science teaching standards (NRC, 1996; 2000). Inquiry included as a content area is viewed from two perspectives: what students should understand about scientific inquiry, and the abilities students develop based on their experiences with scientific inquiry (NRC, 1996; 2000; Barrow, 2006). Inquiry included in the teaching standards addresses teaching strategies associated with inquiry-oriented science activities (NRC, 1996).

Abilities Necessary to do Inquiry

The general recommendations for science as inquiry under the content standards for all three grade spans (K-4, 5-8, 9-12) require students in grades K-12 to develop abilities necessary to do scientific inquiry and to develop understanding about what constitutes scientific inquiry (NRC, 2000). However, even though the general requirements for science as inquiry are the same for grades K-12 the fundamental abilities to do and understand scientific inquiry become more complex from one grade level to another, reflecting the differential expected cognitive development of students at different grade levels. According to the NSES recommendations, the fundamental abilities that students in grades K-4 should develop to do scientific inquiry are as follows (NRC, 2000, p. 19):

- Ask a question about objects, organisms, and events in the environment.
- Plan and conduct a simple investigation.
- Employ simple equipment and tools to gather data and extend the senses.
- Use data to construct a reasonable explanation.
- Communicate investigations and explanations.

Understanding about Inquiry

The fundamental understanding about scientific inquiry that students in grades K-4 should have is as follows (NRC, 2000, p. 20):

1. Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
2. Scientists use different kinds of investigations depending on the questions they are trying to answer.
3. Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using their senses.
4. Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
5. Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations.
6. Scientists review and ask questions about the results of other scientists' work.

Teaching Science through Inquiry

To develop students' abilities necessary to do inquiry and their understanding about inquiry, the NSES emphasize teaching science through inquiry-based pedagogy. The teaching standards outlined below "describe what teachers of science at all grade levels should know and be able to do" (NRC, 1996, p.4):

Teaching Standard A:	Teachers of science plan an inquiry-based science program for their students.
Teaching Standard B:	Teachers of science guide and facilitate learning.

Teaching Standard C: Teachers of science engage in ongoing assessment of their teaching and of student learning.

Teaching Standard D: Teachers of science design and manage learning environments that provide students with time, space, and resources needed for learning science.

Teaching Standard E: Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

Teaching Standard F: Teachers of science actively participate in the ongoing planning and development of school science programs.

To guide and facilitate inquiries, the NSES (NRC, 1996, p. 32) recommend that teachers

1. Focus and support inquiries while interacting with students.
2. Orchestrate discourse among students about scientific ideas.
3. Challenge students to accept and share responsibilities for their own learning.
4. Recognize and respond to student diversity and encourage all students to participate fully in science learning.
5. Encourage and model the skills of scientific inquiry, as well as curiosity, openness to new ides and data, and skepticism that characterize science.

Even though the National Science Education Standards emphasize scientific inquiry as a way to learn and teach science, they do not recommend a single approach to teaching science, but instead emphasize that “teachers should use different strategies to develop the knowledge, understanding, and abilities described in the content standards.

Conducting hands-on science activities does not guarantee inquiry, nor is reading about science incompatible with inquiry" (NRC, 1996, p. 2). According to the National Science Education Standards (NRC, 1996) understanding of teaching inquiry-based pedagogy means that teachers should know that they "can focus inquiry predominantly on real phenomena, in classrooms, outdoors, or in the laboratory settings, where students are given investigations or guided toward fashioning investigations that are demanding but within their capabilities," or that they can use an inquiry approach to "guide students in acquiring and interpreting information from sources such as libraries, government documents, and computer data-bases." (NRC, 1996)

Status-Quo of Science Education in U.S. Schools

National surveys indicate that only 33% of elementary teachers in practice indicate familiarity with the NSES document (Weiss et al., 2001). Also, about 25% of elementary teachers surveyed indicated not teaching science at all, and those who did, indicated devoting little classroom time to science instruction (Tilgner, 1990; Weiss et. al., 2001; Wilson et al., 2001).A survey conducted to evaluate the status of science and mathematics education in the nation indicates that though the national standards in science and mathematics are influencing instruction, the extent of impact is limited, that more attention is given to the mathematics standards than the science standards in schools, and that the penetration of the NSES into the American school system is shallow (Weiss et. al., 2001). Additionally, only one-third of the schools surveyed for each grade span, reported making changes in keeping with the NSES. Of these only half reported discussing the NSES thoroughly among the teachers in school, and only 23-30 % of the science program representatives reported being prepared themselves to explain the NSES to their colleagues. In addition, only one-third or fewer schools in each grade span report that their districts are planning staff development based on the NRC Standards (Weiss et. al., 2001).

State of Inquiry Instruction in U.S. Elementary Schools

From the above description of the state of science education in the nation, it is not surprising to note that inquiry has not yet become a characteristic of science practice and that "in classrooms where it does take place, confirmatory exercises and structured inquiries are by far more common than guided or open inquiries" (Windschitl, 2002 p.115). For example, a U.S. Department of Education survey, (1999) on student work and teacher practices in American schools indicates that 69% of the 12th graders surveyed had "never" or "hardly ever" designed and carried out their own investigation. Thirty-seven and 32% of students surveyed in grades 8 and 12 respectively reported that they did not "conduct science projects or investigations that took more than a week or more.

Similar findings were made by a study conducted to evaluate quality of science and mathematics lessons in grades K-12. Specifically, the authors found that reform-based lessons were only minimally implemented at all grade levels. The authors ranked 59 % of the science lessons evaluated nationally as low quality, 27 % as medium quality and only 15 percent as high quality. Science lessons that were judged high quality shared a number of key elements such as giving students experience with phenomena, making real-life connections, activities that focus on important learning goals, and using contrived contexts to motivate the learners (Weiss et al., 2003). The authors pointed out that "some high quality lessons are 'traditional' in nature, incorporating the use of lectures and worksheets; other high quality lessons were 'reform-oriented', involving students in more open-ended inquiries. In all cases, the lessons that were judged high quality started where the students were, and provided opportunities for students to deepen their understanding" (Weiss et al., 2003, p.103). According to this study, only 16% of the elementary teachers, 27% of middle school teachers, and 20% of high school teachers initiate inquiry in their classroom (Weiss et al., 2003).

Research indicates that many teachers avoid teaching inquiry-based science because their own experiences did not stimulate their interest in science, and what little science is taught in elementary school is done so primarily through lecture and textbooks rather than through exploration and experimentation (Jarret, 1999). In a survey of elementary teachers only about 25% indicated some comfort with using textbooks as a resource rather than as the primary instructional tool even though 99% of the respondents asserted that hands-on manipulative activities should be an important aspect of science instruction (Jarret, 1999). Therefore, one can assume that the inquiry form of teaching and learning science is probably not practiced in most elementary schools today.

Confidence of Elementary Teachers to Teach Science through Inquiry

There are numerous reports in literature indicating that elementary in-service teachers show a lack of confidence and interest in science and in their ability to use the inquiry form of instruction. On a survey conducted to ascertain the science efficacy of in-service teachers, only 27% of elementary teachers surveyed felt qualified to teach life science while an even smaller percentage (18%) felt qualified to teach physical or earth science (Weiss, 1987). Recent surveys of Science and Mathematics Education in the USA report that elementary teachers, though assigned to teach science, mathematics, and other academic subjects to their class, do not feel equally qualified to teach all these subjects and have less extensive backgrounds in science than do their middle school counterparts (Weiss et.al., 2001; 2003; Wilson et al., 2001).

Also, majority of elementary preservice teachers are not familiar with inquiry-based science instruction (Weiss, 2001; 2003). One reason given for this is that efforts to date in science teacher preparation have centered more on teaching scientific content or central concepts and principles and their hierarchy of organization in science than on learning through exploring (Smith, 1999). Additionally, literature reports that the requirement of training preservice teachers in inquiry presents challenges in that (1) scientific inquiry has not been a prominent feature of science teacher preparation (Zembal-Saul et. al., 2000), (2) that prospective teachers have never been engaged in learning science as inquiry or been exposed to effective, inquiry-based instruction and therefore do not understand it (Haefner & Zembal-Saul, 2004), therefore, preservice teachers are not prepared to incorporate scientific inquiry into their teaching practices (Roth et al., 1998). Consequently, literature reports that most elementary teachers are not confident to teach science, especially science through inquiry.

Effect of Status Quo in Elementary Schools on NSES Goals

Surveys indicate that only 52 percent of elementary teachers in grades K-4 meet the recommendations of the National Science Teachers Association (NSTA). Thus, the NSES recommendations for teaching and learning science through inquiry are either not being implemented or being implemented minimally in the K-12 classroom (Weiss et.al. 2003).

It is believed that for teachers to focus and support scientific inquiry recommended by the NSES, they must themselves have opportunities to participate in inquiry-based science learning and must experience a constructivist learning environment (NRC, 1996). Therefore the National Science Education Standards for teaching and learning science recommend that "prospective teachers must take science courses in which they learn science through inquiry, having the same opportunities as their students will have to develop understanding (NRC, 1996, p. 60). Therefore, research is urging educators to provide teacher education programs that help elementary preservice teachers develop pedagogical practices and beliefs /dispositions that are consistent with understanding the nature of science (Hart, 2002) and that preparation of elementary and middle school science teachers in addition to coursework in science education should also include balanced conceptual content among life, earth/space, physical, natural resources, and environmental science (NSTA, 1998 as reported in Weiss, et.al., 2001).

Status of Programs to Prepare Elementary Teachers

Exposure to the inquiry form of instruction for elementary preservice teachers occurs through the elementary science education methods course or science field experience internships. Research suggests that methods courses have the potential to shape the practice of new teachers (Abell & Bryan, 1997; Gess-Newsome, 1999). However, literature indicates that in the past only 26 percent of the 50 states required a separate elementary science education methods course for elementary certification and 17 percent required no methods course at all and that opportunities existed for preservice elementary teachers to take a general methods course or no methods course at all (Stedman & Dowling, 1982). Contemporary elementary science teacher preparation programs, require prospective teachers to successfully complete a varying number of courses in arts and sciences in addition to the core of professional courses which typically includes the foundations courses, the methods courses and practice teaching. However, even when an elementary science education methods course is required, it is not known how aligned this course is with the inquiry-based science learning and instruction recommended by the NSES (Barrow, 2006).

Smith and Gess-Newsome (2004) in their review of literature on elementary teacher preparation report that although there are suggested general standards of practice representing “what teacher educators should think about, know and be able to do” (Association of Teacher Educators, 2003, p.1) and existing program standards for the preparation of elementary science specialists (National Science Teachers Association, 1998), there are no explicit standards or universally accepted expectation for elementary science methods courses pointing out that the NSES are not uniformly implemented in the science methods course syllabi (Smith and Gess-Newsome, 2004). Barrow (2006) in his review of the brief history of inquiry points out that same pattern could exist for the implementation of inquiry-based pedagogy in the elementary science education methods courses. For elementary preservice teachers to graduate with the understanding of the NSES recommendations for science as inquiry, it is important to know how the elementary science education methods course syllabi are fulfilling the NSES recommendations for learning and teaching science through inquiry.

Literature indicates that most elementary preservice teachers are placed for the field experience in schools where science is taught by generalists who are required to teach a number of subjects (Jarret, 1999). These mentor teachers therefore do not have time to develop or implement inquiry-based instruction for science or to develop innovative strategies to teach science. Thus, it is possible that pedagogy in elementary classrooms might not provide adequate exposure to inquiry-based science for preservice teachers (Abell, 2006; Anderson, 1997).

What Inquiry Gets Taught to Elementary Teachers

Windschitl (2002) points out that the model of inquiry that preservice science teachers are exposed to in undergraduate science classes are “not unlike the confirmatory laboratory experiences found in high school”(p. 116). Others point out that undergraduate science laboratory class experiences are highly structured inquiry (Trumbull & Kerr, 1993) and that preservice teachers are rarely exposed to discussions about science as a discipline at the college level and do not participate in discussions of how new knowledge is brought into the field (Bowen & Roth,1998). In a study conducted with an elementary science methods class, Shapiro (1996) found that 90% of her students had never experienced science as an investigation, and most of those who had, did so in school science fairs. In another study Roth (1999) found that when elementary preservice teachers with science degrees were asked to conduct an independent inquiry on an ecology topic, they had considerable trouble creating research questions. Thus, there have been calls to integrate inquiry experiences not only into undergraduate science courses but also into teacher education courses (Bencze & Bowen, 2001; van Zee, Lay, & Roberts, 2000). Volkmann et al. (2005) point out that for inquiry-based science to become a reality in today’s schools, “university science courses must model inquiry so that elementary preservice teachers may experience it” and that “breaking the cycle of teacher-centered didactic science instruction is well worth the effort required to initiate inquiry practices” (p. 867).

Confidence of Elementary Teachers to Teach Science

One of the most documented difficulties facing the majority of elementary school teachers is their low level of confidence in teaching science (Appleton, 2006; Abell & Roth, 1992). Research indicates that as a result of low self-efficacy in science, some elementary teachers simply avoid the teaching of science, while others pass on negative attitudes toward science to their students (Czerniak & Chiarelott, 1990; Westerback, 1982).

A national survey of the status of science and mathematics education in the U.S. indicates that only 18-29% of elementary teachers indicate feeling well qualified to teach science, compared to the 76% who indicate feeling very well qualified to teach reading/language arts, and 60% who indicate feeling well qualified to teach mathematics (Weiss et al., 2001). This survey also indicates that about 80 percent of elementary teachers do not major in sciences but major in elementary education completing less than 6 semester hours in science courses Estimates indicate 25% of elementary teachers do not teach science at all, and little classroom time is devoted to science in the classrooms of those who do (Tilgner, 1990). A needs assessment survey, conducted at Kansas State University, to evaluate the elementary preservice teacher education program in science, mathematics and technology education, indicated that most preservice and mentor teachers ranked science, mathematics, and technology teaching lowest in terms of confidence and experience (Parker et.al., 1989).

Effect of Science Education Status-Quo on NSES Goals

Literature informs us that the vision of science education in the U.S is to inculcate scientific literacy in all students, that the NSES recommendations for teaching and learning science through inquiry-based pedagogy is the way to achieve this national vision (NRC, 1996). Research indicates that both preservice teachers and elementary teachers report anxiety and negative attitudes about teaching science (Westerback, 1982; Czerniak & Chiarelott, 1990), that most elementary preservice teachers have not engaged in learning science as inquiry or been exposed to inquiry-based instruction (Haefner & Zembal-Saul, 2004; Hayes, 2002; Weiss, 2001; Anderson, 2002), that elementary teachers do not receive adequate preparation in the theory and practice of inquiry (Radford, 1998; Rutherford & Ahlgren, 1990), that the majority of elementary teachers are not familiar with the NSES recommendations, do not devote much time to teaching science (Weiss et.al., 2001) and struggle to implement inquiry because of personal dilemmas or other barriers, (Anderson, 2002; Colburn, 2000; Newman et al. 2004; Wee et al., 2007; Crawford, 2007; Newman et. al., 2004) Consequently inquiry is not being implemented by elementary teachers in their classrooms (Weiss et al., 2003; Hayes, 2002).

Research also informs us that the elementary science methods course is a good avenue for providing exposure to inquiry-based pedagogy and for improving preservice teachers' self-efficacy to teach science (Palmer, 2006; Hunker & Madison, 1997; Bleicher, 2006; Wheatley, 2000; 2001; Rice & Roychoudhury, 2003). However, literature indicates that the NSES teaching standards and hence inquiry-based teaching strategies for science, are not uniformly incorporated into the elementary science education methods courses across the country (Smith & Gess-Newsome, 2004; Barrow, 2006) and that preservice teachers placement for the field experience in schools where science is taught by generalists, might not provide exposure to inquiry-based science pedagogy recommended by the NSES (Abell, 2006). Taken together these findings indicate that prospective elementary teachers graduating from teacher preparation programs might not be prepared or confident about understanding of inquiry or inquiry-based pedagogies for teaching science.

Thus, literature informs us that even though learning to teach is a difficult task in itself (McDonald, 1992), implementation of inquiry in the classroom presents its own challenges (Volkmann & Abell, 2003; Hayes, 2002). Therefore, the goals of the NSES standards are only being met minimally (Weiss et.al.,2003). Some of the reasons cited in the literature why teachers are not implementing inquiry in the science classroom include the beliefs, values, and goals that support their teaching orientation being at odds with those that support inquiry (Volkmann et. al., 2005), the lack of self-efficacy to teach science (Enochs, Scharmann, & Riggs, 1995, Weiss et al., 2001), lack of class time to implement inquiry, lack of school support and school systems to implement inquiry and the increased extent of time it takes to prepare inquiry-based lessons. However, no research study to date has examined understanding of teachers and preservice teachers about inquiry or inquiry-based pedagogy or its possible relationship to implementation of inquiry within the classroom.

Statement of the Problem

Most research in literature on teaching of nature of science focuses on the preservice or inservice teachers’ understanding of the nature of science (Bianchini & Colburn, 2000; Kelly, Chen, & Crawford, 1998; Lederman, 1992; Lederman, Wade & Bell, 1998) and their reflections on learning science in a constructivist environment or their confidence to teach science after going through a methods course, field experience or specialized inquiry-based science content courses (Bebout et.al., 1992; Downing & Filer, 1999; Friedrichsen, 2001; Hancock & Gallard, 2004; Jarret, 1999; Lee, Hart, Cuevas & Enders, 2004; McLoughlin & Dana, 1999; Jones, et.al., 1997; McArthur, Duran & Hook, 2004).

To date no research exists that has specifically examined preservice teachers' perceptions regarding their understanding of inquiry and inquiry-based pedagogy and their confidence to teach science after concurrently completing the elementary science education methods course and the science field experience, two avenues available for prospective elementary teachers to learn, observe or formulate pedagogical strategies in science consistent with the NSES recommendations for inquiry-based instruction and learning in science (NRC, 1996).

A previous study conducted by the author to examine experiences of elementary preservice teachers in a content-specific field-based experience with elementary specialists indicates that preservice teachers embrace the reform-based pedagogy of the specialists (Varma & Hanuscin, 2007) who mentor them in the field experience. Therefore, as preservice teachers begin to form their beliefs about learning and teaching science, their perceptions of their experiences in the elementary science education methods course and science field experience can provide valuable information for the evaluation of the elementary science education methods course and the associated science field experience in meeting the recommendations of the NSES for teaching and learning science as inquiry.

UMC Elementary Teacher Education Program

At the University of Missouri-Columbia, elementary education majors are required to take 12 semester hours of biological, physical and mathematical science courses. Laboratory courses in biological and physical sciences are required. In addition, students take subject specific elementary education methods courses such as the elementary education science methods course (3 semester hours) along with the associated field experience. The science methods course and its science field experience are taken within the same semester.

Purpose Statement

The purpose of this research was to determine from elementary preservice teachers' perspectives their understanding about inquiry and inquiry-based pedagogy and their confidence to teach science after concurrently completing the traditional elementary science education methods course and science field experience at the University of Missouri-Columbia (UMC).

Specifically, the intent was to find out what the elementary preservice teachers report regarding their understanding of scientific inquiry, their understanding of the value of inquiry-based pedagogy for teaching science, their comfort with using the inquiry form of instruction and their confidence to teach science after concurrently completing the traditional elementary science education methods course and its associated science field experience. This is especially important since inquiry-based instruction and learning is believed to help students learn about the nature of science and scientific concepts and is the vision of national science education reforms (AAAS, 1990, 1992; NRC, 1996, 2000).

The findings from this research study have implications for the design of the elementary science education methods course and its associated field experience.

Research Questions

This research was guided by the following questions:

1. In what ways are inquiry-based science teaching and learning strategies recommended by the National Science Education Standards integrated / emphasized in the elementary science education methods course at the University of Missouri-Columbia?
2. What do elementary preservice teachers report regarding their understanding of inquiry and inquiry-based science instruction after concurrently completing the elementary science education methods course along with the science field experience at the University of Missouri-Columbia?
3. What do elementary preservice teachers report regarding their confidence (self-efficacy) to teach science after concurrently completing the elementary science education methods course and science field experience at the University of Missouri-Columbia?

CHAPTER TWO

This chapter is organized into three parts. The first part presents the theoretical framework guiding this research study. The second part covers the review of specific research that was used to inform the current study, while the third part is a review of literature related to this research study.

Theoretical Framework

This research study is framed in the literature for elementary preservice teachers' efficacy to teach science, the importance of the inquiry form of science instruction recommended by the NSES (NRC, 1996) and in the ability of individuals to draw meaning from their experiences. The theoretical perspective most relevant to this research is the phenomenological perspective. However, other perspectives such as Bandura's (1977) theory of social learning, the constructivist perspective, and Dewey's (1938) theory on experiential learning are also relevant to this research study.

Inquiry & the Constructivist Perspective

Inquiry-based pedagogical strategies are framed by the cognitive constructivist theory. According to this theory, learning is a process of building up structures of experience where prior knowledge and experiences add to new understandings (Shank, 1993). The theoretical perspective of cognitive constructivism enables one to examine changing thinking about science teaching and learning. This study examines preservice teachers' perceptions regarding their understanding of inquiry and inquiry-based pedagogy in three dimensions: the abilities that students should possess to do scientific inquiry, the understanding students should have about scientific inquiry and how teachers should teach science through inquiry.

Inquiry in science learning has been a recurring theme in science education (Bybee 2000; Chiappetta & Adams, 2000; DeBoer, 1991; Schwab, 1962; Trowbridge & Bybee, 1990). The premise is that in order to provide more hands-on, minds-on experiences where students are central to the learning process, inquiry-based teaching techniques must be used (Tamir, 1990). Therefore, research is urging educators to provide teacher education programs that help preservice teachers develop pedagogical practices and beliefs/dispositions that are consistent with the current education reform (Hart, 2002).

Inquiry is very prominent in both the NSES teaching and content standards (NRC, 1996). Teaching and learning by inquiry has been referred to the way in which teaching and learning is executed, the nature of classroom instructions and to the practice of inquiry skills (Chiappetta & Adams, 2000; Downing & Filer, 1999; Tamir, 1990). Understanding of scientific inquiry includes both processes for testing knowledge and also processes for generating knowledge (NRC, 1996; Duschl, 1990).

Developing an inquiry-based science program is a central tenet of the NSES. According to Colburn (2000) and Barrow (2006), the most confusing thing about inquiry is its definition. There is a lack of agreement on the meaning of inquiry in the field of science education (Martin-Hauser, 2002; Minstrell & van Zee, 2000). For example, Barnam (2002, as referenced in Barrow, 2006) considers inquiry as a teaching strategy and set of student skills (i.e. individual process skills), while Lederman (2002, 2003 as referenced in Barrow, 2006) equates inquiry with the knowledge about inquiry, and Minstrell (2000 as referenced in Barrow, 2006) defines inquiry as: encouraging inquisitiveness, a teaching strategy for motivating learning, hands-on and minds-on, manipulating materials to study particular phenomena and stimulating questions by students (Barrow, 2006).

Anderson (2002) raises the question: “what does it mean to teach science as, through, or with inquiry? Is the emphasis on science as inquiry, learning as inquiry, teaching as inquiry or all of the above?” (p.1).The NSES note this dichotomy in the definition of inquiry below:

> A multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, interpret data; proposing answers, explanations, and predictions; and communicating the results” (NRC, 1996, p.23)

According to Anderson (2002), there are several usages of inquiry in the NSES, but only three main ones, each being distinct from the other, namely: scientific inquiry which is the “diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work” (NSES, 1996, p. 23); inquiry learning which is a learning process in which students are engaged in active hands-on, minds-on learning through a “range of activities” (NSES, 1996, p. 23) and is directly related to the nature of scientific inquiry; while inquiry teaching refers to the “activities of students in which they develop knowledge and understandings of scientific ideas, as well as an understanding of how scientists study the natural world” (NSES, 1996, p. 23).

Anderson (2002) points out that inquiry in the teaching context is “seen both as a characteristic of a desired form of teaching and as a central kind of activity. In either case, there is no precise operational definition and even though the NSES has some specific teaching examples, the reader is left to create his or her own images of what constitutes this form of teaching” (p. 3). Thus, inquiry teaching is defined differently by different researchers in that researchers might use a term for an approach that others would identify with the inquiry label (Anderson, 2002).

The NSES document emphasizes that inquiry-based teaching “does not imply that all teachers should pursue a single approach to teaching science” (p.2), instead, the NSES state that “Inquiry into authentic questions generated from student experiences is the central strategy for teaching science” (p.2). Additionally, the NSES document acknowledges that not all inquiries are the same and distinguishes between a “full inquiry” and a “partial inquiry” and between a “guided inquiry” and an “open inquiry” (p.143).

Barrow (2006) in his brief review of history of inquiry points out that the inclusion of inquiry into the K-12 science curriculum was first recommended by John Dewey who encouraged an emphasis on science thinking and teaching science with inquiry where the teacher’s role was to facilitate and guide learning, and that Schwab was the first to propose that science be taught in a way that was consistent with the way modern science operates suggesting the use of inquiry-based science instruction. Schwab called this instruction “enquiry into enquiry” (Duschl & Hamilton, 1998, p. 1060).

Inquiry as a goal for scientific literacy for all was first articulated in the NSES (1996) policy document. The NSES provide guidance on what science students are to know, how teachers are to teach science and how teachers are to assess students. Inquiry in the NSES is for the first time included as a content area that is viewed from two perspectives: what students should understand about scientific inquiry and the abilities that students should develop based on their experiences with scientific inquiry. Inquiry in the NSES also includes teaching strategies associated with inquiry-oriented science activities. The NSES encourage combining of science processes with scientific knowledge, reasoning and critical thinking so students can develop a richer, deeper understanding of science (NRC, 1996; Bybee, 1997).Thus, contemporary reform efforts in science education, including the NSES, emphasize the importance of children learning science through inquiry (NRC, 1996).

Literature indicates that scientific inquiry complements the nature of science instruction and that the inquiry form of science instruction can be used to teach students the concepts and processes of the nature of science (NRC, 1996; Bianchini & Colburn, 2000). It is also known that greater emphasis on inquiry methods as a medium for development of personal meaning can lead to higher student achievement in the sciences (Anderson, 1997; Von Secker, 2002). The inquiry form of instruction is believed to be important because it engages students in the investigative processes which help them learn science through doing (NRC, 1996; Haefner & Zembal-Saul, 2004). Inquiry-based experiences are believed to help students learn science concepts and to understand how science knowledge is generated and accepted (Haefner & Zembal-Saul, 2004). Yet inquiry remains largely unimplemented in the classrooms (Weiss et.al., 2001).

The main route for preservice teachers to learn pedagogy in specific subjects is through the education methods courses for that subject. Evidence exists indicating that a mathematics methods course can change preservice teachers’ beliefs and attitudes to be more consistent with the current reform movement in mathematics education and positively impact their self-efficacy towards the subject (Wilkins & Brand, 2004). Similarly, in a study conducted to examine the impact of science methods courses, student teaching and science content courses on elementary preservice teachers’ science teaching self-efficacy, researchers found significant gains in the Personal Science Teaching Efficacy (PSTE) for elementary preservice teachers and attributed these gains in self-efficacy to the program design (Morrell & Carroll, 2003). It is not known how aligned the elementary science education methods courses and science field experiences are with the inquiry-based science learning and instruction recommended by the science reform movement and the NSES. Accordingly, one of the goals of this study was to examine the reflections of preservice elementary teachers' regarding their understanding of science as inquiry and teaching science as inquiry following the elementary science education methods course and science field experience.

Self-Efficacy & Bandura's Theory of Social Learning

Research recommends that preservice elementary teachers possess a high degree of self-efficacy in teaching science in order to positively influence their students about learning science (Cannon, 1999). Science self-efficacy is defined as one's self-confidence in relation to teaching science (Enochs, Scharmann, & Riggs, 1995). Self-efficacy or the extent to which teachers believe they can influence student learning is important for effective teaching (Enochs & Riggs, 1990). A low self-efficacy of a teacher to teach elementary science can result in stress and anxiety about teaching science (Enochs & Riggs 1990). Several studies suggest that teacher self-efficacy beliefs may account for individual differences in teacher effectiveness (Palmer, 2006; Huinker & Madison, 1997; Rice & Roychoudhury, 2003; Bleicher, 2006; Armor et. al., 1976; Brookover et.al., 1978; Brophy & Evertson, 1981) and student achievement (Ashton & Webb, 1982).

Surveys indicate that one reason inquiry is not being implemented in the elementary classroom is because of low teacher self-efficacy in science (Weiss et. al., 2003). Research has found positive relationships between a variety of productive teacher behaviors and high self-efficacy ratings (Tschannen-Moran, Hoy, & Hoy, 1998). Therefore, one way to encourage implementation of inquiry-based pedagogy in the classroom could be to improve self-efficacy of teachers to teach science through inquiry. Preparing prospective teachers, who possess self-efficacy in inquiry, may increase the likelihood of them teaching science using inquiry-based pedagogy.

The self-efficacy or confidence of preservice elementary teachers to teach science is framed by Bandura's (1977) theory of social learning which suggests that people develop a generalized expectancy concerning action-outcome contingencies based upon their own life experiences. They also develop specific beliefs concerning their own ability to cope. Behavior of people is dependent on both types of beliefs. Therefore, according to Bandura, people's behavior is consistent with the desired outcomes and the belief in their own ability to perform or their own self-efficacy. When the theory of Bandura is applied to the study of teachers, it is believed that teachers "who believe student learning can be influenced by effective teaching (outcome expectancy beliefs) and who also have confidence in their own teaching abilities (self-efficacy beliefs) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence student learning" (Gibson & Dembo, 1984, p.570).

Literature indicates that self-efficacy is a predictor of behavior (Tschannen-Moran, Hoy, & Hoy, 1998). Bandura (1981) defines self-efficacy as a situation-specific construct. Enochs and Riggs (1990) contend that specificity is especially important when studying elementary science teaching behavior and beliefs since elementary teachers teach all subjects and may not be equally effective in teaching all of them.

Bandura presents four potential sources that may impact self-efficacy and outcome expectations: performance accomplishment or mastery experiences, vicarious experience, verbal persuasion, and physiological and emotional cues (Bandura, 1977). Bleicher (2006) points out that performance accomplishment derives from personal practical experience, that vicarious experience involves a person observing another's performance and gaining confidence, that verbal persuasion from others can influence one's confidence either positively or negatively and that the stress of performance relays emotive information that can affect one's self-efficacy. Bandura (1977) points out that 'perceived self-efficacy' contributes significantly to the level of motivation and performance accomplishments. According to Bandura, self-efficacy of individuals can be enhanced through modeling and successful mastery experiences such as those acquired through methods courses and field experiences (Bandura, 1981). This contention is substantiated by research that has shown that the science field experience is important in improving preservice teachers' self-efficacy to teach science (Wilson, 1996).

A number of studies have examined the relationship between the science methods course and the development of science teaching self-efficacy as defined by Enochs & Riggs (1990). For example, Enochs, Scharmann and Riggs (1995) found evidence that self-confidence, or self-efficacy, could be developed through activities in which science teaching methods were modeled. Similarly, Huinker & Madison (1997) found that elementary education students' science teaching efficacy improved when their mathematics and science methods courses modeled student-centered, inquiry-based teaching strategies. Others have called for a more comprehensive and fundamental vision for changing the science methods course that challenges the traditional roles of teacher and student (Abell & Bryan, 1997).

Reports in literature indicate that field experiences help preservice teachers become more reflective (Hines & Mussington, 1996; Abell & Bryan, 1997), reinforce and challenge beliefs held by them (Hancock & Gallard, 2004), positively affect their personal science teaching efficacy beliefs (Cannon, 1999), and enhance their ability to understand and explain instructional observations (Pryor & Kuhn, 2004). In addition it has been reported that teachers rate student teaching or field experience as the most valuable aspect of their teacher education program (McIntyre & Byrd, 1996).

Consistent with these findings, research suggests that one method of improving the attitudes and self-efficacy of teacher trainees towards science is the inclusion of an early science field experience during the preservice program (Cannon, 1999) where preservice teachers are placed for the field experience with mentor teachers who possess positive attitudes about the nature and teaching of science (Ginns & Foster, 1983) and the second is the involvement of preservice teachers in student-centered, inquiry-based activities through the methods courses (Huinker & Madison, 1997). Accordingly, one of the goals of this study was to understand how the traditional elementary science education methods course, along with its associated science field experience, contributes to the preservice elementary teachers' confidence/self-efficacy to teach science. The findings can provide valuable insight into the design of the science methods course and its associated field experience.

Field Experience and John Dewey's Experiential Learning

According to Bandura (1977), mastery experiences such as those obtained through the science field help improve self-efficacy of preservice teachers. Further, literature indicates that when field experience is integrated into the methods course, the preservice teachers' abilities to understand and explain instructional observations increase (Pryor & Kuhn, 2004). Therefore, the quality of the field experience for preservice teachers is important not only to their self-efficacy but also to their understanding of science pedagogies.

The rationale for a quality field experience for preservice teachers is grounded in the work of John Dewey (1938) who emphasized learner-centered instruction and was an advocate of providing experiential training to teachers. According to literature, Dewey viewed teachers as learners and consequently advocated the need for these learners to be provided experiences through which they could construct their own learning (Huling, 1998). Field experiences are a step in the fulfillment of this vision. However, according to research reports, field experiences have often been fragmented and lack coherence (Smith, 1992). It has been pointed out that sending prospective teacher candidates to observe in schools does not result in substantive learning needed to become successful science teachers (Huling, 1998). According to research, for elementary preservice teachers to understand the critical aspects of science teaching and interactions they must be exposed to quality science instruction within the classroom and must be encouraged to interpret or reflect on instructional strategies they observe in the field (Abell & Bryan, 1997). Reflection can help preservice teachers build the complex schema required to effectively teach science at the elementary level (Hufford, 2000; Abell & Bryan, 1997).

Studies have shown that disconnect between coursework and field experience is a barrier to the development of the ability to frame a theoretical explanation of classroom practice (Metcalf & Kalich, 1996; Goodlad et.al., 1990; Beyer, 2001). Thus, educators point out that observation of classroom practice can help elementary preservice teachers understand how to teach (Clift & Thomas, 1996; Rauch & Whittaker, 1999). Therefore, to develop pedagogical practices consistent with the recommendations of the NSES, participation in a quality science field experience is important for preservice elementary teachers.

Literature indicates that when field experience is integrated (in this case held at the school site) into the methods course, the preservice teachers' abilities to understand and explain instructional observations increase (Pryor & Kuhn, 2004). At the University of Missouri-Columbia, the elementary science education methods course and the science field experience though not integrated on a school campus are required to be taken concurrently in the same semester. Taking these two courses concurrently should help students anchor their science pedagogy theory with field observations of teaching.

Therefore, the overreaching goal of this study was to examine from the preservice teachers' perspectives how the elementary science education methods course and the science field experience, taken concurrently in the same semester, help the preservice teachers construct and refine their ideas about science teaching and learning, or help their understanding of the inquiry form of instruction, or help them develop confidence to teach science at the elementary level.

Review of Related Research

In this section, I present a review of specific research that informed my study. The papers I discuss in this section cover two dimensions namely: (1) elementary preservice teachers' experiences with inquiry in the science methods course (Newman et. al., 2004) and the science field experience (Hayes, 2002) and (2) elementary preservice teachers' self-efficacy beliefs as a result of the science methods course (Huinker & Madison, 1997) and the science field experience (Cantrell, Young, & Moore, 2003).

The Huinker & Madison (1997) research paper used the STEBI-B instrument to capture self-efficacy and outcome expectancy data for preservice teachers to teach science. This study was relevant to my study because it used the STEBI-B instrument to measure self-efficacy and also because the science teaching self-efficacy assessment was done in context of the science methods course. The paper by Cantrell et. al. (2003) is relevant to my research because it evaluates the factors affecting science teaching efficacy of preservice teachers after their science field experience and the methods course and also because it addresses gender specific differences related to self-efficacy.

The paper by Newman et. al. (2004) is relevant to my research because it talks about the dilemmas faced by elementary preservice teachers and instructors in an inquiry-based science methods course. This research helped me put into perspective the findings from my research. The paper by Hayes (2004) is relevant to my research because it articulates preservice teachers' struggles to define inquiry-based pedagogy during implementation of inquiry-based lessons in the field. This research was used to put into context the frustrations and apprehensions faced by preservice teachers in my study.

Inquiry Experiences in the Elementary Science Methods Course

Most studies have not directly addressed inquiry in preservice science teacher education (Newman et. al., 2004). One of the aims of this research study was to capture elementary preservice teachers' understanding of inquiry-based pedagogy after completing an elementary science education methods course. Newman et al. (2004) point out that the purported lack of teacher understanding and skills must be addressed in the methods course and that the potential challenges that face future teachers in inquiry teaching must be an explicit part of science methods instruction. Thus, because of the multiple definitions for inquiry in science education literature and in the classroom practice, examining how inquiry is taught in the elementary science methods course , and how the students respond and understand inquiry-based pedagogy is important in creating a successful teacher education program.

Newman et al. conducted a study to capture the experiences/dilemmas faced by the instructors and the students (preservice teachers) during the study of inquiry in an elementary science methods course and how inquiry is taught in the elementary science methods course. The researchers deigned an elementary science methods course to examine how they taught inquiry in the science methods course. The elementary science methods course under study was built on a reflection orientation (Abell & Bryan, 1997) that provides opportunities for students to build theories of science teaching and learning. This course had been used by the researchers previously to examine the development of teacher thinking about science teaching and the nature of science (Abell & Bryan, 1997; Abell, Bryan & Anderson, 1998; Abell, George & Martini, 2001).The research questions that guided the study included the following: "How are we currently teaching inquiry?

What aspects of inquiry instruction seem to be working well and what aspects are not working well? What factors influence inquiry instruction in our course? How can we address any identified problems? "(p. 260). The science methods instructors in this study created fictional journal entries, using field notes, instructor anecdotal notes, student products, and course artifacts, to represent the experiences of both the instructors and the students during the instruction on inquiry. Results of this study identified seven dilemmas namely: (1) varying definitions of inquiry; (2) instructors' struggle to provide sufficient inquiry-based science experiences, (3) perceived time constraints, (4) determining how much course time should be slated for science instruction versus pedagogy instruction, (5)instructors' and students' lack of inquiry-based learning experiences, (6) grade versus trust issues, and (7) students' science phobias. This study provides important insight into experiences of both students and instructors involved in an elementary science methods course. Knowledge of the dilemmas faced by both preservice teachers and the instructors in the elementary science methods course will help put the findings of my study in proper perspective.

Inquiry Experiences in the Science Field Experience

Teaching science through inquiry recommended by the NSES, demands that preservice teachers engage in a much more difficult process of re-conceiving their roles and identities as teachers. As a result, conflicts and struggles permeate preservice teachers' articulations of their professional roles and identities as a science teacher (Helms, 1998). Literature indicates that the struggle for science teachers to construct a particular kind of identity is often articulated as tension between competing versions of good teaching practice which are combinations of personal visions and cultural expectations (Hayes, 2002).Volkmann & Anderson (1998) suggest that the teacher in their study worked to negotiate the tensions between possible versions of science teacher identity, such as the caring teacher who is expected to nurture the students and the tough teacher who is expected to maintain control in the classroom. Similarly, Bryan and Abell (1999) describe the conflicts and struggles a preservice teacher in their study faced developing her professional identity.

The apprehensions and concerns preservice teachers face regarding the implementation of inquiry-based science in their classrooms, was informed by the study conducted by Hayes (2002) to examine how one class of elementary preservice teachers engaged in productive struggles to understand and implement an inquiry teaching unit in their field-placement setting. Twenty-two elementary preservice teachers enrolled in the elementary science methods course and in their third semester of a four-semester intensive field-based teacher education program were the participants in this study. Preservice teachers' experiences of implementing inquiry-based lessons in their field placement were captured through their reflections in journals, written documents, the final project produced by the preservice teachers to meet the course requirements and the instructor's reflections about his observations of events that occurred during his guiding of inquiry in class (Hayes, 2002). The preservice teachers were required to keep daily journals of their experiences implementing their inquiry projects then produce a three to five page summary of the project. Methods of qualitative analysis were used to organize the contents of these documents into descriptive categories which were used to identify themes around which the preservice teachers organized their experiences (Hayes, 2002).

Results of this study indicate that preservice teachers struggled with their emerging identities and roles as facilitators, voiced concern about removing themselves out of the traditional authoritarian role as a teacher within the classroom and struggled to construct categories of meaning for their teaching practice which were articulated around three notions, namely: letting go, going with students' interests, and asking the right questions. Hayes (2002) points out that the theory and practice of inquiry science teaching moved the elementary preservice teachers from an identity that was safe, sure, and comfortable to an identity that was unsettled, uncertain and uncomfortable. However, through their struggles came an appreciation of inquiry-based learning as they began to create a new vision of their role as teachers under reform based science. Experiences of the preservice teachers are relevant to the findings from my study about the frustrations and apprehensions faced by preservice teachers as they define their role as science teachers and shape their pedagogical practices.

Self-Efficacy and the Elementary Science Methods Course

Research indicates that preservice teachers' beliefs about science and science teaching and learning are responsible for limiting their development as teachers in elementary methods courses (Rice & Roychoudhury, 2003; Palmer, 2006; Cantrell, Young, & Moore, 2003). Enochs and Riggs (1990) developed a valid and reliable instrument (the Science Teaching Efficacy Belief Instrument, STEBI-B) based on Bandura's two component self-efficacy model. The STEBI-B is composed of two subscales, the Personal Science Teaching Efficacy Belief (PSTE) and the Science Teaching Outcome Expectancy (STOE). This instrument has been used by several researchers to explore issues of self-efficacy in preservice teachers. For example, the

STEBI-B instrument was used by Bleicher and Lindgren (2005) in a study of the learning cycle and self- efficacy. Tosun (2000) used it to study the effects of prior science coursework on self efficacy. Palmer (2006) used it to examine the relative importance of various sources of self-efficacy in an elementary science methods course and found that the main source of self-efficacy was cognitive pedagogical mastery. Bleicher (2006) used it to examine changes in personal science teaching self-efficacy, outcome expectancy, and science conceptual understanding and relationships among preservice teachers, while Morrell & Carroll, (2003) used it to evaluate the impact of science methods courses, student teaching, and science content courses on elementary preservice teachers' science teaching self-efficacy. The study by Huinker and Madison (1997) which was helpful in informing my study is discussed below.

In a study conducted to evaluate the impact of methods courses on preservice teachers' personal efficacy beliefs and outcome expectancy beliefs in science and mathematics teaching, researchers captured self-efficacy and outcome expectancy data for preservice teachers to teach science (Huinker & Madison, 1997). Results of this study indicate that the methods course consistently had a positive influence on the preservice elementary teachers' beliefs in their ability to teach science (Huinker & Madison, 1997). The authors point out that the success of the science methods course in enhancing preservice teachers' teaching efficacy beliefs is consistent with the four principles posited by Bandura for self-efficacy namely, performance attainments, vicarious experiences, verbal persuasion and physiological states. According to the researchers' explanation, preservice teachers had positive experiences as learners of science and mathematics during the methods courses. These experiences influenced their physiological states as they realized learning science and mathematics did not have to be stressful or anxiety provoking and could be enjoyable. Additionally, researchers reported that as learners of science and mathematics, the preservice teachers had vicarious experiences where they observed the professors modeling teaching strategies. Researchers point out that it is possible that the preservice teachers visualized themselves performing similarly as teachers in their own classrooms. According to Bandura (1986), “self-efficacy can be readily changed by relevant modeling influences when people have had little prior experience on which to base evaluations of their personal competence.” (p. 399-400). In addition to the methods courses, the preservice teachers in this study had vicarious experiences in the field as they observed classroom teachers and their peer partners. These types of experiences influenced preservice teachers’ efficacy beliefs as they persuaded themselves that if others can do it, they should be able to do it too. Verbal persuasion, according to the researchers was a subtle but pervasive aspect of the methods courses as both professors felt responsible to convince the preservice teachers that they could be effective teachers of science and mathematics. According to Bandura (1986), people who are persuaded verbally that they possess the capabilities to successfully perform given tasks are likely to put forth greater sustained effort that promotes the development of skills. Performance attainment was achieved through teaching lessons in the field and observing the enthusiasm of the children to learn. This study shows that content methods courses with a field component can contribute to preparing efficacious elementary teachers in science and mathematics as these courses allow them to function both as learners and teachers.

Self-Efficacy and the Science Field Experience

In a study conducted by Cantrell, Young & Moore (2003) to examine the efficacy beliefs of a sample of elementary preservice teachers at three stages of their program starting with introductory methods seminar courses, followed by the advanced methods course, and in the field placements, researchers explored the relationships between the levels of efficacy beliefs and various factors such as gender, prior science experiences, and science teaching time. A total of 268 elementary preservice teachers participated in this study. Data was collected at the end of each successive level of coursework namely: seminars, advanced methods, and student teaching in the field. However, due to scheduling conflicts, only 12 preservice teachers appeared in all three data sets and were accordingly referred to as the embedded group. Thus, data for 154 seminar preservice teachers, 84 methods preservice teachers, and 54 preservice teachers in the field experience were collected across the three semesters with the embedded group appearing in each set. The STEBI-B instrument was used to assess science teaching efficacy in this study.

Results indicate that there was a moderate gender effect on the PSTE beliefs in the seminar group with males scoring higher which was attributed in part to the fact that 59.3% of the males in the sample reported taking 4 to 5 years of high school science courses compared to only 33.3% of females and to the slightly higher percentage of males (42.9%) participation in the high school extracurricular science activities compared to the females (38%). The difference in PSTE between males and females for the methods group was zero. Interestingly none of the males in this group reported participating in extra curricular science activities in high school, while only 17% of the females reported participating. The percentage of males (57.1%) in this group taking more than the required two years of science was similar to the percentage of females (63.6%).For the preservice teachers in the field experience/student teaching group, the gender effect was moderately low and once again none of the males reported that they had participated in extra-curricula activities in high school, while 32.6% of the females did. A higher percentage of males (85.7%) in this group reported taking more than the required two years of college science compared with 55.4% of the females. Another factor that seemed to give rise to large effect sizes on PSTE was the amount of time spent by preservice teachers in teaching science to children in an elementary classroom in the field. The largest increase in PSTE was for the preservice teachers in the methods group who were able to teach science to children for more than 3 hours across the span of their 3-week practicum in the field. This suggests that there may be a significant increase in PSTE with the first successful science teaching experiences, which is supported by Bandura’s (1997) suggestion that mastery experiences help to increase efficacy beliefs. The researchers concluded that the methods courses might be the most appropriate time to provide science teaching experiences in order to develop preservice teachers’ efficacy beliefs. The only significant effect found for STOE occurred in the group of preservice teachers involved in student in the field. Interestingly, preservice teachers in this group who had taken more than the required number of college science content courses had higher STOE scores than those who took only the required courses. The authors point out that this increase could be explained by the fact that the practice of teaching science caused the student teachers group to draw upon their content knowledge and training most recently completed at the university and by doing so their outcome efficacy beliefs were positively impacted. About 75% of the preservice teachers in the student teacher or field group reported taking more than the required amount of science courses at the college level, compared to only 32% of the seminar group and 27% of the methods group. Thus, the authors concluded that (a) providing early field experiences for preservice teachers that include science lesson plan development and delivery for a sustained period of time, and (b) methods classes which provide safe and ample opportunities for vicarious experiences, positive physiological and emotional arousal, and social persuasion with respect to successful science teaching experiences can enhance preservice teachers PSTE beliefs and STOE beliefs in science. This study is relevant to my research as it addresses the impact of the science field experiences and gender on preservice teachers' self-efficacy to teach science.

Review of Related Literature

Science Education Reforms

To improve science education in grades K-12, a number of national reports have stressed the need for major improvements in the preparation of teachers. The Holmes Group (1986), the National Commission on Teaching & America's Future (1996), and others (National Commission on Excellence in Education, 1983; Goodlad, 1990; Darling-Hammond, 1997; AAAS, 1990; 1992) have recommended that preservice teacher candidates should be exposed to more rigorous preparation and meaningful experiences to help them understand and handle the complexity, challenges, and diversity of today's classrooms. Accordingly, science educators and researchers have called for the redesign of preservice teacher preparation programs (Beeth & Rissing, 2003; McDermott, 1990). This call for reform includes inquiry-based learning/teaching (Chiappetta & Adams, 2000; NRC 1996; NRC, 2000) and exposure to a quality field experience to provide meaningful experiences to improve teachers' confidence to teach science (Haefner & Zembal-Saul, 2004; Carnegie Forum, 1986; Committee on Science and Mathematics Teacher Preparation, 2001; The Holmes Group, 1990). Thus, the reform movement in science education is trying to address problems in science education identified over the last decades namely, lack of science teaching taking place in elementary schools, lack of confidence in elementary preservice or in-service teachers to teach science, and the limited science content and science pedagogical knowledge of elementary preservice and in-service teachers (Appleton, 2006).

There is evidence that preservice teachers benefit from active, learner-centered constructivist environments (Brindley, 2000; Holt-Reynolds, 2000; Kelly, 2000; Lowery, 2002). Some have suggested that science for preservice teachers should be taught in a way that develops preservice teachers' understanding of science content and pedagogy (Barr, 1994; Fraser-Abder, 1992; Raizen & Michelsohn, 1994; National Center for Improving Science Education, 1989a; 1989b) and should be closely tied to elementary classroom curricula to develop the preservice teachers' confidence to teach science (DeTure et.al, 1990). Others report that learning science is more meaningful for preservice teachers when it is framed within a context of science pedagogy and that the confidence to teach science is most enhanced through activities-based experiences and pedagogically-oriented assignments (McLoughlin & Dana, 1999).

While the primary focus of the science education reform movement has been on teachers and the teaching of science, the recent national surveys of science and mathematics education in the United States (Weiss et.al., 2001; 2003; Wilson et al., 2001) points out that not only teacher preparedness but a number of factors such as school and district policies and practices as well as administrator and community support, effect student learning of science and mathematics. Responses on this survey on the issues or problems effecting science instruction in the elementary grades indicates a lack of time to teach science, lack of teacher preparation to teach science, lack of time available for professional development in science, lack of time for teachers to plan and prepare science lessons, and a lack of opportunities for teachers to share ideas or to work with each other during the school year (Weiss, et.al., 2001).

Elementary Preservice Teacher Preparation

Educators believe for teachers to construct views about the nature of science, preservice teacher preparation programs need an increased emphasis on science content, science processes, and methods and inquiry-based instructional strategies (Lederman, 1998; NSTA, 1983; 1998).

The NSES (NRC, 1996; 2000) point out that for preservice teachers to focus and support scientific inquiry recommended by the NSES, they must themselves have opportunities to participate in inquiry-based science learning and must experience a constructivist learning environment. The two avenues for preservice teachers to learn inquiry-based science instruction is through science education methods courses and the science field experience.

However, literature indicates serious deficiencies in the preparation of elementary teachers to teach science (Weiss et. al., 2001; 2000; Wilson et al., 2001) pointing out that science education programs for preservice teacher preparation are inadequate in both content and pedagogical strategies (Weiss et. al., 2001; Fort, 1993; McDermott, 1990;

NRC, 1996). This is supported by the findings of the National Commission on Teaching and America's Future (1996) that a number of licensed teachers lack adequate content knowledge. Others have pointed out that science course work is often separated from practice and that the traditional design, delivery and structure of university science courses is not supportive of improving or influencing the science-literacy level or self efficacy of future elementary or middle school science teachers. (Duran, McArthur & Van Hook, 2004).

An important concern of science educators has been to promote preservice teachers' understanding of science in a way that encourages effective science teaching consistent with the vision of elementary school science (McLoughlin & Dana, 1999; NRC, 1996). Many elementary education graduates express their lack of science content expertise, and pedagogical content expertise and consequently do not feel confident to teach science (Downing & Filer, 1999). Further, most undergraduate introductory science courses taken by elementary education majors today may or may not expose them to scientific investigations or inquiry. Some researchers question whether the one elementary science education methods course requirement typical of the elementary teacher education programs can foster elementary science teaching consistent with science-as-inquiry grounded in the constructivist epistemology which requires that learners be treated as active members of the knowledge-building (McLoughlin & Dana, 1999).

Accordingly, the reform movement of undergraduate science education has suggested that college level science courses be taught in a manner that challenges and develops future teachers' science content understandings through specially designed experiences. In other words educators have called for science being taught in an investigative manner, emphasizing the central concepts and tools of scientific inquiry mentioned in the NSES (McLoughlin & Dana, 1999; NRC, 1996).

In keeping with the above call for the reform of college science content courses for prospective teachers, science learning experiences of prospective teachers are being evaluated through participation in specially designed science content courses built around the recommendations outlined in the NSES (NRC, 1996). For example, a study examining the prospective elementary teachers' learning about scientific inquiry in context of an innovative life science course, found that engaging preservice teachers in scientific inquiry supported their development and understanding of science and scientific inquiry and made them more accepting of approaches to teaching science that encourage children's questions about science phenomenon (Haefner & Zembal-Saul, 2004). Similarly, in a mathematics content course designed to help preservice teachers develop a solid foundation for standards-based methods course, researchers found positive changes in the students' beliefs, attitudes and perceptions on how mathematics should be taught and learned (Lubinski & Otto, 2004).

Abell and Roth (1992) point out that "science content courses for preservice elementary teachers may be more effective if they are taught in conjunction with elementary science education methods courses instead of separately and prior to the methods course" (p. 593). In keeping with this contention, McLoughlin & Dana (1999) through a specially designed integrated science content/methods course demonstrated that learning science was most meaningful to prospective teachers when it was framed within a context of science pedagogy, and included activities based experiences and pedagogically oriented assignments.

Elementary Preservice Teacher Preparation in Science Pedagogy

In the area of teacher perceptions of their preparation to teach science and to use the various instructional strategies recommended for science by the NSES (NRC, 1996), the National Survey of Science and Mathematics Education in the USA (Weiss et.al., 2001) indicates that in the elementary grades (K-6) teachers on an average spend only 23-31 minutes per day teaching science as compared to the 96-115 minutes a day they spend teaching reading/language arts or 52-60 minutes per day they spend teaching mathematics (Weiss, et.al., 2001).

Regarding teacher pedagogical beliefs, the National Survey of Science and Mathematics Education (Weiss et. al., 2001) revealed that science teachers as a whole were much less likely to be familiar with the National Science Education Standards released by the National Research Council. In this survey only 33 percent of elementary school science teachers showed familiarity with the National Science Education Standards recommendations compared to 62 percent of high school and 58 percent of middle school science teachers who showed familiarity with the recommendations of the NSES (Weiss, et. al., 2001). The encouraging statistic in this survey was that the majority (70 %) of the science teachers showing familiarity with the NSES recommendations indicated their agreement with the vision of the standards and expressed their intent to implement the NSES recommendations (Weiss, et. al. 2001).

The above statistics are especially important in light of reports in literature of studies analyzing student achievement data which indicate that student achievement gains are much more influenced by the student's assigned teacher than by other factors such as class size and composition (Sanders & Rivers, 1996; U. S. Department of Education, 2002). This is supported by studies evaluating the effectiveness of teachers in the classroom which attribute at least 7% of the total variance in students' test-score gains to differences in teacher effectiveness (Rivkin, et. al., 2001). The implication of these findings is that preservice teacher preparation programs are very important to producing teachers who are confident and effective in teaching science.

There is considerable debate in literature on how much influence is exerted by education programs on the pedagogy in class and student learning, and whether education coursework or content or both are needed for training future teachers in science and mathematics. Some studies examining the relationship between teacher qualifications and student achievement indicate that subject matter degrees have a greater effect on teacher effectiveness than certification (Darling-Hammond & Youngs, 2002). For example, the U.S. Department of Education's (2002) Annual Report on Teacher Quality titled "Meeting the Highly Qualified Teachers Challenge" points out that there is little evidence that education school work leads to improved student achievement indicating that the current teacher certification programs are inadequate. This report recommends higher standards for verbal and content knowledge and interestingly de-emphasizes requirements for educational coursework for preservice teacher preparation (U.S. Department of Education, 2002).

However, Darling-Hammond & Youngs (2002) contend that teacher preparation and certification have a stronger influence on student achievement above and beyond the effects of teachers' subject matter degrees indicating that while a good grasp of one's subject area is necessary it is not sufficient for effective teaching. They point out that in a longitudinal study of American students researchers found that while teachers' college coursework in the subject field usually positively impacts student achievement in science and mathematics, it is the education course in the subject matter methods that has a positive effect on student learning at all grade levels (Monk, 1994 as stated in Darling-Hammond & Youngs, 2002). This is supported by school level studies in California (Betts et. al., 2000) and Texas (Fuller, 2000) which found that teacher's education training and certification impacts student achievement.

Most educators agree that a multitude of factors influence teacher effectiveness in bringing about student learning. Teacher attributes identified for effectiveness of teaching include teachers (a) general academic and verbal ability; (b) subject matter knowledge; (c) knowledge about teaching and learning as reflected in teacher education courses or preparation experiences; (d) teaching experience; and (e) the combined set of qualifications measured by teacher certifications (Darling-Hammond et. al., 2001; Darling-Hammond and Youngs, 2002).

Types of Inquiries within the Classroom

It is believed that one of the most important contributions a teacher can make to students' future successes in education is to provide them with ample opportunities to learn and use science process skills or inquiry (NRC, 1996). The NSES recommend that "at all stages of inquiry, teachers guide, focus, challenge, and encourage student learning" (NRC, 1996, p. 3). Colburn (2000) has described inquiry–based instruction as the "creation of a classroom where students are engaged in essentially open-ended, student-centered, hands-on activities."

The National Science Education teaching standards among other things expect preservice teachers to (a) plan an inquiry-based science program; (b) guide and facilitate student learning through inquiry-based science; (c) develop communities of science learners; (d) design and manage learning environments for effective use of time, space, and resources for learning/teaching science (NRC, 1996).

The NSES points out that the type of scientific inquiry conducted depends upon the amount of guidance provided by the teacher. The NSES describe inquiries as 'partial' or "full". According to the NSES, full inquiries are those where all five of the essential elements of classroom inquiry are present whereas partial inquiries are those investigations where one or more essential features for classroom inquiry are missing such as when the "teacher chooses to demonstrate how something works rather than have students explore it and develop their own questions or explanations," or when a teacher "does not engage students with a question but begins by assigning an experiment (NRC, 2000, p.28).

According to the NSES, inquiry-based teaching can vary in the "amount of structure, guidance, and coaching the teacher provides for students engaged in inquiry" (NRC, 2000, p. 28). The degree to which teachers structure what students do is sometimes referred to as 'guided' versus 'open' inquiry. The more responsibility learners have for posing and responding to the questions, designing investigations, extracting and communicating their learning, the more "open" the inquiry, while the more responsibility the teacher takes, the more structured or guided the inquiry (NRC, 2000). The Standards also point out that students rarely have the abilities to begin with open inquiries and that experiences that vary in 'openness' are needed to develop the abilities necessary to do inquiry and that “guided inquiry can best focus learning on the development of particular science concepts” while a “more open inquiry will afford the best opportunities for cognitive development and scientific reasoning” (NRC, 2000, p.30). The Standards recommend that students should have “opportunities to participate in all types of inquiries in the course of their science learning” (NRC, 2000, p.30). The nature of the inquiry used to teach science depends upon whether the teacher wants students to “learn a particular science concept, acquire certain inquiry abilities, or develop understandings about scientific inquiry (or some combination)” (NRC, 2000, p.30).

Colburn (2000) defines inquiry-based instruction as the “creation of a classroom where students are engaged in essentially open-ended, student-centered hands-on activities” (p.42). This definition embraces several different approaches to inquiry-based instruction, as articulated below (Colburn, 2000, p.42):

Structured inquiry- The teacher provides students with hands-on problem to investigate, as well as the procedures, and materials, but does not inform them of the expected outcomes.

Guided inquiry- The teacher provides only the materials and problem to investigate. Students devise their own procedure to solve the problem.

Open Inquiry-This approach is similar to the guided inquiry, with the addition that students also formulate their own problem to investigate. Open inquiry, according to Colburn, in many ways is similar to doing science.

Learning cycle-Students are engaged in an activity that introduces a new concept. The teacher then provides the formal name for the concept. Students take ownership of the concept by applying it in a different concept.

In the science classroom envisioned by the NSES, effective teachers "continually create opportunities that challenge students and promote inquiry by asking questions" (NRC, 1996, p.3). Some educators believe that only teachers who have themselves mastered inquiry related skills can successfully pass them on to their students (Downing & Filer, 1999). Research reports that teachers express weakness in their own understanding of science processes and do not feel confident to facilitate conceptual development in their students (Downing & Filer, 1999). The consequence of this discomfort with science is that many teachers minimize their involvement with science instruction as a method of coping with science anxiety (Downing & Filer, 1999).

To date some of the initiatives that have emerged to prepare prospective teachers to teach science as inquiry include offering a teacher preparation curriculum that emphasizes inquiry such as courses with modified content that engage preservice teachers in science inquiry as learners (Zembal-Saul et al, 2000; Hudson, 2004; Jarvis et al, 2001). Research has shown that prospective teachers respond positively when exposed to inquiry-based instruction in their undergraduate science content classes and become more accepting of approaches to teaching science that encourage children's questions about science phenomena (Haefner & Zembal-Saul, 2004). Also preservice teachers who were exposed to the inquiry form of instruction in their science courses reported being better prepared to teach science (Powell, 2003). For example, in a specialized inquiry-based science biology course, preservice elementary teachers transitioned from initial feelings of hesitation to feelings of improved confidence and self-efficacy (Friedrichsen, 2001). What is not known is how effective the elementary science education methods courses are in teaching inquiry-based science pedagogy to prospective teachers. To date no study has examined elementary preservice teachers' perspectives on their understanding and teaching of inquiry-based science after completing a science methods course.

Science Instructional Models

Historically learning has been classified into three broad categories namely: transmission, maturation, and construction of knowledge (Bybee, 1997). The instructional model (Table 1) proposed by J. F. Herbart (Bybee, 1997) was one of the first systematic approaches to teaching and has been used in various forms by educators to allow students to discover the relationships among experiences.

Table 1: Herbart's Science Instructional Model (Bybee, 1997, p.170)

Preparation	The teacher brings experiences to students' awareness.
Presentation	The teacher introduces new experiences and makes connections to prior experiences.
Generalization	The teacher explains ides and develops concepts for students.
Application	The teacher provides experiences where the students demonstrate their understanding by applying concepts in new contexts.

John Dewey's instructional approach (Table 2) was based on the belief that learning occurs through diverse experiences and reflective thinking to synthesize those experiences.

Table 2: Dewey's Instructional Model (Bybee, 1997, p.171)

Sensing perplexing situations	The teacher presents an experience where the students feel thwarted and sense a problem.
Clarifying the problem	The teacher helps the students identify and formulate the problem.
Formulating a tentative hypothesis	The teacher provides opportunities for students to form hypotheses and tries to establish a relationship between the previous experiences.
Testing hypothesis	The teacher allows students to try various types of experiments, including imaginary, pencil-and-paper, and concrete experiments, to test the hypothesis.
Revising rigorous tests	The teacher suggests tests that result in acceptance or rejection of the hypothesis.
Acting on solution	The teacher asks the students to devise a statement that communicates their conclusions and expresses possible actions.

Dewey's approach is consistent with the contemporary NSES approach of both hands-on and minds-on experiences in science. Embedded in his approach is the model of scientific inquiry.

Piaget's model of equilibration explains how learning occurs. According to Piaget, intellectual development occurs through an "adaptation in response to a discrepancy between the individual's current cognitive structure and a cognitive referent in the environment. Disequilibrium results from a discrepancy. Modification of intellectual structures brings the cognitive system back to equilibrium" (Piaget, 1975 as cited in Bybee, 1997, p.172). In Piaget's mode, organization (the maintenance of an internal order of intellectual structure) and adaptation (changing the intellectual structure through interaction with the environment) bring about equilibration. The learning cycle proposed by J.M. Atkin and R. Karplus is based on Piaget's theory of learning and is the basis of a number of contemporary instructional models incorporating inquiry-based instructional strategies teaching science. The three phases of the learning cycle model of instruction are represented in Table 3.

Table 3: Piaget's Learning Cycle Model (Bybee, 1997, p. 175)

Exploration	Unstructured experiences in which students gather new information. This phase involves the process of knowledge assimilation.
Invention	The invention phase begins the process of accommodation that allows interpretation of newly acquired information through the restructuring of prior concepts. Refers to a formal statement, often definition, of a new concept.
Discovery	This phase involves application of the new concept to another novel situation. During this phase, the learner continues to move closer to a state of equilibrium and to a new level of cognitive organization (integration of the new concept with related concepts).

Teaching science through inquiry is grounded in the constructivist paradigm that learning is constructed by the learner. The constructivist view assumes a "dynamic and interactionist conception of human learning in which students bring to the learning experience their current explanations, attitudes, and skills. Through meaningful interactions between themselves and their environment, which includes other students and teachers, they redefine, replace, and reorganize their initial explanations, attitudes, and skills" (Bybee, 1997, p.167).

The 5E instructional model proposed by Bybee (1997) is based on the constructivist paradigm and includes the structural elements of the Atkin and Karplus learning cycle model. The 5E model has the following five phases which are designed to facilitate the process of conceptual change in students:

Engagement- In this phase, the teacher designs experiences intended to make connections with current concepts and skills and to bring into question the adequacy of those concepts and skills. This phase brings about disequilibrium.

Exploration-In this phase and social interactions (cooperative learning)to give students concrete, meaningful experiences, upon which they can continue to build concepts, processes, and skills. This phase initiates the process of equilibration.

Explanation- In this phase, the students have the opportunity to articulate their ideas to their peers and the teacher, and the teacher helps students clarify their ideas through scientific and technological terms and concepts. This phase is teacher directed.

Elaboration- In this phase, the teacher provides activities based on the same concepts and skills, but there is a new and different context. The students must expand or generalize their new conceptions to the different experiences.

Evaluation- In this phase, the teacher uses a variety of assessments to determine the students' conceptual understanding and level of skill development. This phase also is an opportunity for students to test their understanding and skills.

The 5E instructional model represents a systematic and coherent approach to teaching science and is supported by the following 4 factors: (1) educational research on conceptual change, (2) congruence of the model with general processes of scientific inquiry and technological design, (3) utility of the model for designing and developing curriculum materials, and (4) practical use by science teachers (Bybee, 1997, p.186). The 5E instructional model is consistent with the five essential features of classroom inquiry outlined by the NSES (Table 4) and the expected student outcomes defined in the NSES Teaching Standard B (Table 5).

Table 4: NSES Essential Features for Classroom Inquiry versus 5E Instructional Model

Essential Features of Classroom Inquiry (NRC, 2000)	**5E Instruction Model** (Bybee, 1997)
Learners are **engaged** by scientifically oriented questions.	**Engage** in independent problem solving in a constructivist environment.
Learners give priority to **evidence,** which allows them to develop and evaluate explanations that address scientifically oriented questions.	**Explore –**Oral and written discourse.
Learners formulate **explanations** from evidence to address scientifically oriented questions.	**Explain** conceptual understanding.
Learners **evaluate** their explanations in light of alternative explanations, particularly those reflecting scientific understanding.	**Evaluate** and understand skills and behavior that drive inquiry.
Learners **communicate** and **justify** their proposed explanations.	**Elaborate** and develop deeper understanding.

Table 5: NSE Teaching Standard B and the 5E Learning Cycle Instructional Model

National Science Education Teaching Standard B Recommendations (NRC, 1996)	**NSE Content Standard For Science as Inquiry-Expected Student Learning Outcomes K-4** (NRC, 1996)	**5E Instruction Model** (Bybee, 1997)
Focus and support inquiries while interacting with students.	-Plan and conduct a simple investigation.	**Engage** Independent problem solving in a constructivist environment.
Orchestrate discourse among students about scientific ideas.	-Ask questions. -Record data and observations.	**Explore –** Oral and written discourse.
Challenge students to accept and share responsibility for their own learning.	-Use data to construct a reasonable explanation. -Use secondary sources-media, books, journals in library to develop deeper understanding.	**Explain** conceptual understanding. **Elaborate** and develop deeper understanding.
Encourage and model the skills of scientific inquiry, as well as curiosity, openness to new ideas and data.	-Curiosity, asking and answering questions. -Develop explanations based on data / knowledge. -Communicate/share findings with peers.	**Evaluate** and understand skills and behavior that drive inquiry.

The NRC (2000) commentary on teaching and learning science through inquiry, acknowledges the existence of a number of different instructional models for use by teachers to “organize and sequence inquiry-oriented learning experiences for students” (NRC, 2000, p. 34). The NRC commentary points out that each of these models can incorporate, to varying degrees, the following five essential features of teaching science through inquiry proposed by the NSES (NRC, 2000, p. 25) namely:

1. Learner engages in scientifically oriented questions.
2. Learner gives priority to evidence in responding to questions.
3. Learner formulates explanations from evidence.
4. Learner connects explanations to knowledge.
5. Learner communicates and justifies explanations.

Thus, according to the NSES, the inquiry-based instructional models should seek to engage students in important scientific questions, give students opportunities to explore and create their own explanations, provide scientific explanations and help students connect these to their own ideas, and create opportunities for students to extend, apply, and evaluate what they have learned (NRC, 2000). Although the NSES recommend teaching science through inquiry, they are very emphatic in pointing out that this should not be the only way of teaching science and that other methods can also be used. The use of the 5E instructional model helps students and preservice teachers develop abilities necessary to do inquiry and understanding of classroom inquiry as outlined in the Standards (Bybee, 1997).

Research on Science Field Experience

Researchers report that learning science is more meaningful for preservice teachers when it is framed within a context of science pedagogy and that confidence to teach science is most enhanced through activities-based experiences and pedagogically-oriented assignments (McLoughlin & Dana, 1999). Research indicates that field experiences help preservice teachers to become reflective, think deeply and critically and transition from being students to teachers (Abell & Bryan, 1997; Hines & Mussington, 1996; Murray-Harvey, 2001; Korthagen & Kessels, 1999). Research has also shown that learning from field experience is enhanced when it is integrated into formal coursework (Pryor & Kuhn, 2004). Studies have shown that when field experience is integrated into the methods course, the preservice teachers' abilities to understand and explain instructional observations or frame a theoretical explanation of classroom practice increases (Metcalf & Kalich, 1996; Goodlad et.al., 1990; Beyer, 2001; Sunal, 1980; Pryor & Kuhn, 2004). In a multi campus research study examining what role mathematics methods courses could play in providing preservice teachers with an understanding of mathematics for teaching, researchers concluded that methods courses are the logical place to bring the subject matter expertise of college professors together with the pedagogical understanding of expert teachers (Floden et.al, 1996).

Some have suggested that science for preservice teachers should be taught in a way that develops preservice teachers' understanding of science content and pedagogy (Barr, 1994; Fraser-Abder, 1992; Raizen & Michelsohn, 1994; National Center For Improving Science Education 1989a; 1989b) and should be closely tied to elementary classroom curricula to develop the preservice teachers' proficiency in science process skills and improve confidence to teach science (DeTure et.al, 1990).

Educators consider the field experience along with student teaching and the first years of teaching to be an important component of teacher development which helps preservice teachers transition from being student teachers to being effective teachers (DeBolt, 1996). Therefore, field experience or observation of classroom practice is an important part of teacher education as it helps preservice teachers understand pedagogy

(Clift & Thomas, 1996; Rauch & Whittaker, 1999). Through field experiences, teacher candidates observe and work with real students, teachers and curricula in school settings. Research indicates that elementary preservice teachers who are provided increased amounts of or an extended field experience remain in their profession through the induction years in greater numbers than those who receive less field experience or those prepared through traditional campus-based programs (Houston & Huling, 1998).

Research also reports that effective field experience is important for preservice teachers who are required to teach science as inquiry within a constructivists' epistemology and that exposure to a quality field experience can help reduce teachers' anxiety and improve their confidence to teach science (Haefner & Zembal-Saul, 2004).

Review of research on field experience indicates that most teacher education programs require field experience (McIntyre & Byrd, 1996). Observation of classroom practice has been shown to help preservice teachers understand how to teach (Clift & Thomas, 1996; Rauch & Whittaker, 1999).The field experience can consist of one or both components of practicum namely early field experience (placements in classrooms prior to student teaching) and student teaching. The most prevalent field experience until the early 1980s was student teaching, however in recent years more and more students are being placed in classrooms where they can observe a veteran teacher as part of their early field experiences (Huling, 1998). Reports in literature claim that early field experiences result in better prepared teachers (Huling, 1998). Early field placements expose prospective teachers to classroom experiences prior to becoming involved in student teaching and are a good place for preservice teachers to observe teaching strategies which could ultimately shape their own pedagogy (Huling, 1998).

Literature indicates that the context of field experiences is affected by a number of factors including the nature or location of the field experience and support received from mentor teachers (Guyton & McIntyre, 1990; Zeichner & Gore, 1990). It is believed that mentor teachers are a very critical component of the field placement (Paes, 1996). Mentoring has been identified as a way to help prospective teachers develop confidence and pedagogy. To achieve this goal mentor teachers must possess attributes such as awareness of system requirements, pedagogical knowledge, and the ability to model and provide meaningful feedback (Hudson, 2004). It is believed that the mentor's pedagogical knowledge is the key for providing quality field experiences within preservice teacher education programs (Briscoe & Peters, 1997; Kesselheim, 1998). Increasingly educators are calling for mentor teachers who are critical, analytical thinkers or "problem solving coaches" (Ponticell & Zepeda, 1996). This is consistent with the recommendation from educators that teacher education programs provide high quality experiences at each step in the training of a new teacher (DeBolt 1996; Diez, 1995).

Literature indicates that teachers are not being placed with proper mentor teachers (McIntyre & Byrd, 1996) where training is consistent with science teaching reforms (NRC, 1996) requiring the understanding of inquiry-based science process skills (Abell, 2006). Literature indicates that most elementary preservice teachers are placed for the field experience in schools where science is taught by generalists who are required to teach a number of subjects (Jarret, 1999). It has been pointed out that mentor teachers therefore do not have time to develop or implement inquiry-based instruction for science or to develop innovative strategies to teach science (Andersen, 1997; Stake & Easley, 1978). Jarvis et. al., (2001) indicate that mentors with who preservice teachers are placed might not be confident to mentor in specific subject areas such as science. According to research the time spent by elementary teachers on K-6 science averages only 10% of the total instructional time available (Goodlad, 1984; Weiss et.al., 2001). It is believed that this lack of time devoted to science and the marginal instructional quality for science in elementary schools can be detrimental to students' achievement, academic preparation, and career awareness (Abell, 1990). Therefore, pedagogy in elementary classrooms does not provide adequate exposure to inquiry-based science for students (Clift & Thomas, 1996).

Thus, to develop teachers who are proficient in teaching in a constructivist environment required by the current science education standards (NRC, 1996), it has been proposed that research needs to examine alternate models of experiences at all levels of teacher education and development (DeBolt, 1996; Guyton & McIntyre, 1990). It is believed that the placement of first year teachers with mentors who successfully model problem solving approaches can help preservice teachers construct and refine knowledge, skills, and values appropriate to teaching (Mager, 1992). The use of science specialists has been suggested as an alternate model for teaching science at the elementary grades (Abell, 1990).

The presence of a science teaching specialist is believed to ensure that science is a regular part of every elementary student's day (Abell, 1990). The specialist is a generalist who is solely devoted to teaching science, has above average knowledge and interest in science, is confident and knowledgeable about teaching science, can communicate positive feelings about science to the students, and uses pedagogical practices consistent with science reform goals. Therefore, the specialist model for elementary science instruction can provide the quality mentorship needed to help prospective teachers develop confidence and pedagogy in science (Abell, 1990; Olson,1992).

Review of literature on field experience for preservice teachers indicates that early field placements have been fragmented (Smith, 1992), that most field experiences are not well designed or successful in inculcating confidence in elementary preservice teachers to teach (Zeichner & Gore, 1990; Zeichner, 1992) and that tensions are likely to result from participation in field experience (Hancock & Gallard, 2004; Black-Branch & Lamont, 1998). In addition, Metcalf and Kahlich (1996) in their review of the last 25 years of the field experience component of teacher education programs point out that many teacher education programs are not able to provide meaningful field experiences because there has been a saturation of school sites with an increasingly heavy load placed mentor teachers who are reluctant to work with preservice education students.

Field experience is helpful in inculcating positive attitudes in prospective elementary teachers for teaching science and for exposing them to the inquiry form of instruction (Bryan & Abell, 1999). Additionally, research has shown that when preservice teachers exchange ideas and reflect together with their peers, they develop into reflective thinkers and form the support networks needed to alleviate stress (Beyer, 2001; Casey, 1994). Reflection is considered an effective methodology to draw connections between theory and field observations (Abell & Bryan, 1997; Doecke et.al, 2000).

Disconnect between the field experience and the coursework, is believed to have a negative effect on the development of preservice teachers' ability to frame a theoretical explanation of classroom practice (Goodlad et al., 1990; Beyer, 2001). Thus, researchers question whether the placement of preservice teachers for the field experience in schools as they exist today is adequate for the development of teachers who are reflective, and who are confident in teaching science (Abell, 2006; Zeichner, 1986; McIntyre & Byrd, 1996).

Research Gap

Research indicates that both elementary and preservice teachers have not been exposed to inquiry-based pedagogy recommended by the NSES (Haefner & Zembal-Saul, 2004) and lack self-efficacy to teach science (Appleton, 2006). Research also indicates that science methods courses can improve the personal science teaching efficacy of elementary preservice teachers (Palmer, 2006; Bleicher, 2006; Morrell & Carroll, 2003), and provide inquiry-based experiences to preservice teachers. However, literature indicates that the NSES are not uniformly implemented in the science methods courses and therefore it is possible that inquiry is not uniformly implemented in these courses (Smith & Gess-Newsome, 2004). Preservice teachers learn pedagogical practices in both the science methods course and the science field experience. Research suggests that when the science methods course is integrated with the field component, it helps preservice teachers anchor their learning about pedagogy with classroom practice (Pryor & Kuhn, 2004).

To date no research exists that has examined from preservice teachers' perspectives the contribution of the traditional elementary science education methods course and the science field experience to developing their understanding of inquiry-based pedagogy, their confidence to teach science and the development of their pedagogical strategies for teaching science through inquiry as recommended by the NSES (NRC, 1996).

Research shows that reflective thinking facilitates learning for preservice teachers (Abell, 2006; Abell & Bryan, 1997; Hines & Mussington, 1996; Murray-Harvey, 2001; Korthagen & Kessels, 1999; Doecke et. al., 2000). As preservice teachers begin to form their beliefs about learning and teaching science, their perceptions of their experiences in the elementary science education methods course and science field experience can provide valuable information for the evaluation of the elementary science education methods course and associated field experience in meeting the recommendations of the NSES for teaching science as inquiry.

Therefore, the goal of this research was to capture preservice teachers' perceptions of their understanding of scientific inquiry, inquiry-based pedagogy for teaching science as recommended by the NSES and their confidence to teach science after concurrently completing the elementary science education methods course and the science field experience. The findings from this research are expected to help with the improvement or design of pedagogical experiences for preservice teachers offered through the elementary science education methods course and the associated science field experience.

CHAPTER THREE

The goal of this research was to capture the elementary preservice teachers' perceptions regarding their understanding of inquiry-based science instructional strategies and their confidence to teach science as a result of concurrently completing the elementary science education methods course and science field experience at the University of Missouri-Columbia. Therefore this inquiry was guided by the phenomenological perspective which attempts to understand the meaning of events and interactions from the point of view of participants (Douglas, 1976).

Phenomenological inquiry attempts to understand the conceptual world of the subjects and is the search for understandings and meanings that the involved participants, themselves, hold about an object, person, or situation (McLoughlin and Dana, 1999). Reflections are an important component of phenomenological research as they help to recapitulate the participants' experiences to create a reflective cognitive stance through which meaning can be assigned to events and interactions experienced by people (Van Manen, 1990). Also, literature points out that course discussion and reflection using the preservice teachers' field observations and classroom learning are critical to their ability to integrate theoretical understandings in making sense of school observations (Pryor & Kuhn 2004; Bogdan & Bilken, 2003; Abell & Bryan, 1997).

Research Design

This research study was designed as a qualitative study with a quantitative component. The major emphasis was on qualitative methodology. This is because qualitative research has the capacity to enable inquirers to identify the understandings held by individuals and the meanings they make of their experiences (Erickson, 1998).

According to Glaser and Strauss (1999) there is no fundamental clash between the purposes and capacities of qualitative and quantitative methods or data. According to these authors the generation and comparison of both forms of data on the same subject can help generate findings that are grounded in data.

The design of this research study is consistent with the characteristics defined for naturalistic inquiry (Lincoln & Guba, 1985, p.39-45) in that this research used human instruments for primary data gathering; was conducted in the natural setting of the students (classroom); used mostly qualitative methods such as interviews and focus groups to capture data as these methods help to deal with multiple realities which are inherent in the perceptions of individuals and can be varied based on the meaning each individual draws from his or her experience even when it is the same for all participants; the research was focused in that boundaries of research were defined and guided by the research questions proposed; trustworthiness of the data was confirmed through comparison of data obtained through multiple sources such as a questionnaire, survey, focus groups, interviews and syllabus evaluation; the researcher elicited meaning and interpretations from the participants reflections by constructions of their multiple realities i.e. responses into categories of meaning and emerging themes; grounded theory principles were used to arrive at conclusions in that the conclusions emerged from the data or were grounded in data; and finally the researcher was aware that individual realities can be multiple and different and may not be duplicated in other settings and therefore refrained from making broad application of the findings.

Participants

The primary respondents in this research were the elementary preservice teachers in the four-year undergraduate teacher education program and enrolled in the elementary science education methods course for the winter 2006 semester at the University of Missouri-Columbia. These students are juniors or seniors going through their science field experience in parallel with the elementary science education methods course during the winter 2006 semester. Junior and senior students are required to maintain a 2.750 MU GPA of record and an overall GPA is required for progression to graduation and certification.

Other participants included in the research were the instructors who taught the two sections of the elementary science education methods course during the winter 2006 semester at the University of Missouri-Columbia (UMC). Both the instructors were informed of the intent and purpose of the research study and assured of anonymity. Anonymity of the instructors was assured by coding their responses on the interview transcripts as P1 and P2. The instructor coded as P1 in this study was a PhD seeking graduate student at the University of Missouri-Columbia, who was teaching the elementary science education methods course in the winter 2006 semester. The instructor coded as P2 in this study, has a Ph.D and is a professor of science education at the University of Missouri-Columbia. Both the graduate student instructor and the professor teaching the science methods course will hereafter be referred to as instructors teaching this course.

Preservice teachers were recruited via email (Appendix E-University of Missouri-Columbia Recruitment email). Permission was obtained from all students who participated in the research. Only students consenting in writing (Appendix F-University of Missouri-Columbia Informed Consent) were used as participants in the study. Forty (40) preservice elementary teachers, ranging from juniors to seniors, consented to participate in the study. Twenty two (22) participants were from one section and eighteen (18) from the second section. All participants were females. Written consent was also obtained from the instructors of the science methods course (Appendix G-University of Missouri-Columbia Informed Consent) before involving them in the study.

In addition, prior to the initiation of the study, the University of Missouri Institutional Review Board (IRB) application was filled out to get approval for the research study and the use of human subjects. The researcher was also required to take and pass an online test for IRB approval to confirm the understanding of IRB rules and processes. Research was only initiated after IRB approval had been received.

Elementary Science Education Methods Course

At the University of Missouri-Columbia, science pedagogy is taught to prospective teachers seeking baccalaureate degrees in elementary education through the elementary science education methods course. The elementary science education methods course is a laboratory and research-based course designed to integrate theory and practice. The goal is to help preservice teachers integrate instructional strategies learned through the elementary science education methods course with their observations of a mentor teacher's instruction in the field. Accordingly, an important component of this course is the field experience placement in the elementary classrooms in the Columbia, Missouri Public Schools usually in grades 4-5. The science field experiences in the Columbia, Missouri Public Schools are geared to allow preservice teachers to observe science teaching techniques and strategies. Students are placed with mentor teachers (science specialist's grades 4-5, or K-3 teachers). Each placement is for two (2) hours per week for at least 12 weeks providing 24 hours of field experience in which the preservice teachers observe delivery of instruction by mentor teachers and on occasions participate in different classroom activities. Thus, through field placements in elementary science classrooms preservice teachers are able to examine the problems of practice and are expected to begin the process of becoming inquiring, reflective professionals.

The methods courses are taught in 'cohorts' or 'blocks' each made up of approximately 20-30 students. Students are enrolled in a 12 credit hour 'block' which includes science, math, and literacy methods courses, and 3 hours of field experience. Each student is assigned to one elementary school (usually grade 4-5) and conducts two hours of science teaching observations per week over one semester. The number of schools that participate in the science field experience usually varies from 4-5 based on the permissions received from the cooperating teachers and the school district. Students are required to observe teaching strategies used to teach science in the schools (field) with limited hands on teaching which usually occurs in the form of helping students with their work or helping the cooperating teacher with the delivery of the lesson. In most cases there is no independent teaching conducted by the students. The elementary science education methods course is divided into two sections each being taught by a different instructor.

Data Sources

The benefit of collecting data from multiple sources is that it allows the researcher to carefully check and cross check whether the researcher's interpretation of data is correct. According to Glaser and Strauss (1999) replication of data is the best means for validating facts. Accordingly, multiple modes of data collection were used in this study, including: (1) focus group sessions capturing preservice teachers' reflective discussions on their confidence to teach science, the teaching strategies discussed and taught in the elementary science education methods course and those observed in the science field experience, and preservice teachers' understanding of inquiry for teaching and learning science, (2) a study specific questionnaire, specifically designed by the researcher for this study, to capture their understanding of scientific inquiry and confidence to teach science following the elementary science education methods course and the science field experience, 3) the Science Teaching Efficacy Belief Instrument (STEBI-B) (Enochs & Riggs, 1990), 4) interviews with the instructors of the science methods course, and 5) examination of the elementary science education methods course syllabus. Table 6 summarizes the research questions and data collection/data analysis strategies. In the following sections, each data source is discussed in further detail.

Table 6: Summary: Research Questions, Data Collection, and Data Analysis

	Research Question	Data Sources	Method of Analysis
1	In what ways are the inquiry-based science teaching and learning strategies recommended by the NSES, integrated /emphasized in the elementary science education methods course at the University of Missouri-Columbia?	Focus Group Transcripts: Preservice Teachers' reflections Interview transcripts : Methods Instructors Evaluation of Elementary Science Education Methods Course Syllabus	Evaluation of transcripts for themes. Evaluation of use of inquiry in the methods course. Review of responses for support of themes. Confirm integration of inquiry into the syllabus.
2	What do elementary preservice teachers report regarding their understanding of inquiry and inquiry-based science instruction after concurrently completing the elementary science education methods course along with the science field experience at the University of Missouri- Columbia?	Focus Group Transcripts Interview Transcripts Study Specific Questionnaire Responses	Evaluation of themes. Review for support of themes. Review for support of themes.
3	What do elementary preservice teachers report regarding the effect, if any, on their confidence (self-efficacy) to teach science after simultaneously going through the elementary science education methods course and science field experience?	Focus Group Transcripts Interview Transcripts STEBI-B Instrument Study Specific Questionnaire	Evaluation of themes. Review for support of themes. Support of themes. Support of themes.

Methodology

Focus Groups

An important part of this research design was to have preservice teachers share their reflections and to comment on each others' understanding. Reflection and dialog among the preservice teachers has been shown by researchers to help preservice teachers learn about teaching and the foundations of education (Hufford, 2000; Kerrins, 1990; Huling, 1998). To capture the elementary preservice teachers' perceptions regarding their understanding of inquiry and inquiry-based pedagogy and their confidence to teach science, focus groups were convened to have preservice teachers reflect on the inquiry-based science teaching strategies learned through the elementary science education methods course and through the science field experience. A series of five focus-group interviews were conducted with students from both sections of the methods course. The focus group technique allows for a semi-structured interview. Focus groups were selected as a method of purposeful sampling (Lincoln & Guba, 1985) of the preservice teachers' perceptions about their understanding of inquiry and their confidence to teach science as a result of going through the elementary science education methods course that integrates the science field experience. Purposeful sampling is desired under the naturalistic paradigm as it allows for the selection of a representative sample for the group under study. By selecting five groups (approximately 5-6 students each) assurance was made to include as much information as possible to give context to the generalizations following from the data (Lincoln & Guba, 1985). Discussions in these focus groups were initiated by the researcher by asking open ended questions. Questions used to stimulate discussions in the focus groups were formulated ahead of time (Appendix A-Focus Group

Protocol Preservice Teachers). The intent of the focus group sessions was to stimulate discussions and reflections among the preservice teachers about their understanding of inquiry and inquiry-based instructional strategies and their confidence to teach science and to determine whether students' understanding of inquiry-based science instruction was consistent with the inquiry form of science pedagogy taught in the methods course. The reflective discussions of the preservice teachers were audio taped and transcribed. Students in each focus group were assigned a numerical number to keep track of responses. Whenever a response was made the numerical number of the respondent was noted down. In this manner responses were coded by group number and respondent number e.g. G1-S4 represents student 4 in group 1. Transcripts from the focus groups served as the primary data source. Focus groups were convened towards the end of the winter semester 2006 when preservice teachers were finishing up their science field experience and the science methods course.

Interviews

Structured interviews were conducted with the instructors teaching each section of the elementary science education methods course in the winter 2006 semester. According to Lincoln & Guba (1985, p. 269), a structured interview is the mode of choice when the interviewer knows what he or she does not know and can therefore frame appropriate questions to find out. As required for a structured interview, the intent of the interview was defined prior to the interview and the interview questions (Appendix B-Interview Protocol-Science Methods Instructors) were formulated ahead of time to elicit respondents' answers "in terms of the interviewers' framework and definition of the problem" (Lincoln & Guba, 1985, p.268).Anonymity of the instructors was maintained by coding their responses on the interview transcripts as P1 and P2 as described earlier. The interviews were conducted towards the end of the 2006 winter semester.

Interview questions were a mixture of convergent (closed) and divergent (open) in nature to allow the gathering of specific information while allowing reflection from the participants. Additional questions were asked during the interviews to stimulate further reflection by the participants. Responses from the interviews with the instructors teaching the science methods course were used to verify the categories and the assertions emerging from focus group data.

Evaluation of Science Education Methods Course Syllabus

To validate the findings from the focus groups and interviews, the elementary science education methods course syllabus for winter 2006 supplied by the instructors was examined to determine what elements, of inquiry and inquiry-based pedagogy recommended by the National Science Education Standards, were explicitly included in the elementary science education methods course. Each lesson module was examined for contents and conformance to the National Science Education Standards' recommendation for learning and teaching science through inquiry. Transcripts from focus groups and from the interviews were also reviewed to confirm the findings from the elementary science education methods course syllabus evaluation. Conversely, the elementary science education methods course syllabus was examined to confirm categories and assertions emerging from the focus group data.

STEBI-B Instrument

The elementary preservice teachers' self-efficacy or confidence to teach science after going through the elementary science education methods course and the science field experience was assessed using the Enochs and Riggs (1990) instrument: STEBI-B (Science Teaching Efficacy Belief Instrument Form B). This instrument was administered in person by the researcher, towards the end of the winter 2006 semester (Appendix C-STEBI-FORM B) during a regularly scheduled science methods class period.This instrument is a modified version of the original Riggs STEBI-A instrument (Riggs, 1988) which was developed to determine elementary inservice teachers' self-efficacy to teach science (Enochs and Riggs, 1990). It consists of 23 items in a 5-choice, Likert-type scale format. Response categories include SA=strongly agree, A=agree, UN=uncertain, D=disagree, and SD=strongly disagree. Of the 23 items in the survey, 13 are designed to address preservice teachers' confidence to teach science or their Personal Science Teaching Efficacy (PSTE) (Morrell & Carroll, 2003). The remaining 10 questions are designed to assess the respondents' belief that teaching can have a positive effect on students or their Science Teaching Outcome Expectancy (STOE) (Morrell & Carroll, 2003). The validity and reliability of the instrument to measure preservice teacher self-efficacy for teaching science has been established (Enochs & Riggs, 1990) through the administration of the survey instrument to 212 preservice elementary teachers (184 females and 27 males) in California and Kansas. In the present study, the STEBI-B instrument was administered to preservice teachers at the end of the winter 2006 semester to determine how the elementary science education methods course and the science field experience had effected their confidence to teach science.

Study Specific Questionnaire-SSQ

The preservice teachers were also administered a study specific questionnaire which was designed by the researcher specifically (Appendix D-Study Specific Questionnaire) to capture preservice teachers' understanding of scientific inquiry and their perceptions regarding the contribution of the elementary science education methods course and the science field experience to their understanding of inquiry-based pedagogy and confidence to teach science. The study specific questionnaire was designed with 20 items in a 5-choice, Likert-type scale format. Response categories included SA=strongly agree, A=agree, UN=uncertain, D=disagree, and SD=strongly disagree. Of the 20 items in the survey, 14 were designed to capture the preservice teachers' understanding and knowledge about scientific inquiry, 3 questions were designed to capture preservice teachers' confidence to teach science and the remaining 3 questions captured their perceptions regarding similarities between science teaching strategies modeled and taught in the elementary science education methods course and those observed in the field. This instrument was administered to the elementary preservice teachers by the researcher towards the end of the winter 2006 semester during a regularly scheduled class period at the conclusion of the elementary science education methods course and the science field experience.

Data Analysis

Data collected from multiple sources was analyzed using principles of grounded theory (Glaser and Strauss, 1999) i.e. data was used to generate assertions and not vice versa. Use of grounded theory is consistent with the naturalistic paradigm that posits "multiple realities and makes transferability dependent on local contextual factors" (Lincoln & Guba, 1985, p. 204) and as articulated by Glaser and Strauss (1967, p.3) in the following statement: "the categories must be readily (not forcibly) applicable to and indicated by the data under study" (Glaser and Strauss, 1967, p.3).

The constant comparison method (Glaser and Strauss, 1967; Lincoln & Guba ,1985; Hatch, 2002) was used to generate categories of meaning and emerging assertions. To get repeated confirmations of the emerging assertions for relevance, comparison was done between data from multiple sources such as transcripts from focus group discussions, transcripts from the methods instructors' interviews, preservice teachers' responses on the Study Specific Questionnaire (SSQ) and STEBI-B instrument, and analysis of the elementary science education methods course syllabus with respect to the National Science Education Standards'(NSES) recommendations for inquiry-based instruction and student learning. The comparison of data collected through multiple sources helped assure that the emerging assertions were grounded in data (Lincoln & Guba, 1985; Hatch, 2002) and assured the trustworthiness of the emerging assertions which is one of the hallmarks of naturalistic inquiry (Lincoln & Guba,1985).

The intent of this study was to have the categories of meaning/assertions emerge from the data i.e. be grounded in data. Focus group audio recordings' transcripts served as the primary data source. The focus group questions were designed to elicit preservice teachers understanding of inquiry, science pedagogy, and their confidence to teach science. Data analysis began by transcribing audio recordings from the focus group sessions and from interviews with the science methods instructors.

Focus group responses were assigned to provisional categories based on similarity and content of responses using the constant comparative method outlined by Lincoln & Guba (1985). This approach has been used previously in research for evaluating preservice teachers' conceptions of science (Abell & Smith, 1994; Bloom 1989), their understanding of scientific inquiry and science teaching and learning (Haefner & Zembal-Saul, 2004), and for capturing undergraduate students perceptions of an inquiry-based physics course (Duran, McArthur & Hook, 2004).

Focus group responses were compared, coded and descriptively labeled into provisional categories using intuitive judgments of "look-alikeness" or "feel-alikeness" (Guba & Lincoln, 1985). Some categories were imminent based on the focus of the research questions, others emerged from reflective responses of preservice teachers captured during the focus group sessions. Categories were compared across groups and continuously refined to identify and capture the emergent patterns within and across the various groups. Emerging categories were re-examined to define the property of each category and responses re-categorized based on the emerging category definitions. According to Glaser and Strauss (1967, p.106), this "constant comparison of incidents very soon starts to generate theoretical properties of categories" which in this case led to the reclassification of some responses to conform to the property of the category. Thus, the emergent categories are qualitatively derived and reflect the participants in this study. Categories were examined for emerging commonalities to identify the emerging themes.

Trustworthiness of the assertions emerging from the focus group data was confirmed through the triangulation of data from multiple sources such as the interview transcripts from the interviews with the methods' instructors, the preservice teachers' responses on the Study Specific Questionnaire and the STEBI-B instrument, and the results of the evaluation of the winter 2006 semester course syllabus for the methods courses. Triangulation of data in naturalistic inquiries is considered important because it allows researchers to validate the data against at least one other source and according to Lincoln & Guba: "No single item of information (unless coming from an elite and unimpeachable source) should ever be given serious consideration unless it can be triangulated" (Lincoln & Guba, 1985, p. 283).

Thus, in this research, assertions emerging from the focus group transcripts were validated through comparison with the transcripts from interviews with the methods instructors. The responses in the interviews were validated through the comparison and evaluation of the course syllabus for the elementary science education methods course for the winter 2006 semester in which this study was executed. The elementary science education methods course syllabus was evaluated for conformance to recommendations for inquiry-based science teaching and learning by the National Science Education Standards specifically to determine what elements of scientific inquiry recommended by the National Science Education Standards are emphasized in the elementary science education methods course at the University of Missouri-Columbia. Finally, preservice teachers' responses on the Study Specific Questionnaire and the STEBI-B instrument and interviews with the elementary science education methods instructors were examined to further confirm and validate the themes emerging from the focus group discussions.

Constant comparison of data from multiple sources was used to provide confidence in the emerging assertions being identified and assured trustworthiness of data required under a naturalistic inquiry (Lincoln & Guba, 1985). Use of the constant comparative method of coding data helped identify the emerging assertions with respect to the preservice elementary teachers' understanding of inquiry-based pedagogy and their confidence to teach science.

Scoring on the response categories ("strongly agree", "agree", "uncertain", "disagree", and "strongly disagree") for the STEBI-B instrument was similar to that used by Enochs and Riggs (1990) to originally validate the STEBI-B instrument. This consisted primarily of assigning 5 to the positively worded items receiving "strongly agree" down to 1 for "strongly disagree". Negatively phrased items had their scores reversed. Possible scores on the PSTE subscale range from 13 to 65 while on the STOE subscale range from 10-50. High scores on the STEBI-B subscale measuring PSTE indicate a strong belief in one's ability to teach science while high scores on the STEBI-B subscale measuring STOE subscale indicate high expectations in regard to the outcomes of science teaching. Scoring on the SSQ was similar to what was done on the STEBI-B.

CHAPTER FOUR

Findings

In this chapter, I present the findings from analysis of data collected from the following five data collection sources:

1. Transcripts capturing preservice teachers' reflections during the focus group discussions
2. Transcripts of interviews with the two methods professor / instructor
3. Assessment of the science methods course syllabus from winter/spring semester 2006 for conformance to the NSES recommendations for teaching and learning through inquiry for grades K-4
4. Results on the STEBI-B instrument which measured the preservice teachers' personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). The two dimensions together served as indicators of the preservice teachers' confidence to teach elementary science
5. Results of the Study Specific Questionnaire which measured the preservice teachers' understanding of inquiry, their confidence to teach science, and synergies between science teaching strategies demonstrated and taught in the science methods course and those observed in the field.

Preservice teachers' reflections captured through the focus groups were used as the primary data to develop descriptive categories of meaning (Lincoln & Guba, 1985). Discussions in the focus groups were guided by the questions listed in Appendix A (Focus Group Protocol-Preservice Teachers). Preservice teachers' responses on the focus group transcripts were grouped according to the category of meaning each response conveyed using the constant comparative method described in chapter 3 (Lincoln & Guba, 1985). The following categories of meaning emerged from the focus group data:

1. Integration of NSES recommendations for science as inquiry into the science methods course
2. Previous exposure to inquiry-based learning
3. Exposure to inquiry-based pedagogy through the science methods course
4. Exposure to inquiry-based pedagogy through the science field experience
5. Influence of science methods course on preservice teachers' understanding of inquiry.
6. Influence of science methods course and science field experience on preservice teachers' understanding of inquiry-based pedagogies to students' learning of science.
7. Preservice teachers' reflections on learning science through inquiry
8. Personal science pedagogy concept development.
9. Preservice teachers' confidence to teach elementary science

Trustworthiness of the data was verified using the constant comparative method (Lincoln & Guba, 1985) where findings from the focus group transcripts were compared against findings from other data collection sources. Data from the interview transcripts, the STEBI-B instrument and from the Study Specific Questionnaire (SSQ) were used to confirm and support the themes emerging from the categories of meaning developed from the focus group data. Scoring on the response categories of the STEBI-B and Study Specific Questionnaire is detailed in chapter 3. Review of the science methods syllabus, course materials, and interview transcripts was done to evaluate how inquiry based instructional strategies recommended by the NSES were integrated into the science methods course. The findings from this set of data were confirmed through the data from the preservice teachers' reflections on the focus groups.

This chapter is organized into three sections according to the research questions to be answered by this study. Section I includes analysis of data pertaining to research question 1, section II includes analysis of data pertaining to research question 2, and section III includes analysis of data pertaining to research question 3. I begin each section by listing the categories of meaning applicable to the research question being addressed. Data in each section is organized under the category of meaning it belongs to. Sub questions, defined by the category of meaning, are used to analyze the data in each section. For example, data in Section I, pertain to research question 1 and is grouped under the following category of meaning:

> Integration of NSES recommendations for science as inquiry into the science methods course

Section II contains data from all instruments grouped under the following categories of meaning pertaining to research question 2:

1. Previous exposure to inquiry inquiry-based learning
2. Exposure to inquiry-based pedagogy through the science methods course
3. Exposure to inquiry-based pedagogy through the science field experience
4. Influence of science methods course on preservice teachers' understanding of inquiry.
5. Influence of science methods and science field experience on preservice teachers' understanding of inquiry-based pedagogies to students' learning of science.

6. Preservice teachers' reflections on learning science through inquiry
7. Personal science pedagogy concept development.

Section III contains data grouped under the following category of meaning pertaining to research question 3:

Preservice teachers' confidence to teach elementary science

Thus, analysis of data is conducted by using sub questions derived from the categories of meaning applicable to the specific research question. Data from all instruments applicable to the category of meaning are discussed under each sub question. Each section is concluded with the summary from that section. At the end of the chapter, I present summary of findings from analysis of data from all five data collection sources.

Section-I-Analysis of Data in Support of Research Question 1

The category of meaning used to generate the sub questions in section I was the integration of NSES recommendation into the science methods course syllabus. This category of meaning is relevant to answering research question 1namely:

Research Question 1:

> In what ways are inquiry-based science teaching and learning strategies recommended by the National Science Education Standards integrated/emphasized in the science methods course at the University of Missouri- Columbia?

The sub question used to analyze the syllabus was as follows:

Q1: How are the inquiry-based science teaching and learning strategies recommended by the National Science Education Standards integrated/emphasized in the elementary science methods course at the University of Missouri-Columbia?

Elementary Science Methods Course Syllabus Analysis

My examination of the science methods syllabus (Appendix I), the course handouts (TDP 4280 at UMC) and reading materials, shows that multiple investigations were designed for preservice teachers to practice and learn abilities required to conduct inquiry and to develop concepts relating to the understanding of classroom inquiry. My examination of the syllabus shows that these investigations were designed to teach preservice teachers abilities and concepts required to do inquiry, while some taught understanding about inquiry. Table 7 provides a listing of week by week activities for the science methods course and shows how these address the expected student learning outcomes outlined by the NSES for fundamental abilities necessary to do scientific inquiry and the fundamental understanding about scientific inquiry for K-4.

Table 6: Elementary Science Methods Course Syllabus Analysis

Expected Student Learning Outcomes	Activities/ Demonstration From Science Methods Syllabus Analysis
General Requirements for Science as Inquiry for Grades K-12 (NRC, 2000)	
1. Develop abilities necessary to do scientific inquiry (NRC, 2000).	Weeks 1-10: Discussion and introduction to the following: • Inquiry and science process skills. • Use of science notebooks to record data and observations. • Use of journals to record reflections. • Involvement in inquiry-based activities. • Presentations of inquiry-based lesson plans and curriculums.
2. Develop understanding about scientific inquiry (NRC, 2000)	Week 1 lesson plan: What Science is appropriate for elementary school? Week 2 lesson plan: Discussion on nature of science. Discussion of constructivist orientation to science. Week 6&7 lesson plan: Discussion of Learning Cycle. Discussion and use of operational questions and effective. questioning strategies to initiate student investigations. Week 8-10 Lesson plan: Preparation and presentation of inquiry based science lesson plans. Discussion and analysis of instruction material for suitability for teaching inquiry. Discussion of assessment strategies to test understanding about science and inquiry.
Fundamental Abilities Necessary to Do scientific Inquiry: K-4 (NRC, 2000)	
Ask questions about organisms, objects events in the environment	Week 1-10: Designing multiple investigations based on prompts

	from the instructor instructors . Taking a trip through the woods and discussing their observations with each other and the professor / instructor.
Plan and conduct a simple investigation	Week 1-10: Multiple hands-on experiments Seeds/pendulums/raisin tonic/magnets/food car/electricity
Employ simple equipment and tools to gather data	Week 1-10: Designing equipment for multiple experiments Seeds/pendulums/raisin tonic/magnets/food car/electricity
Use data to construct an reasonable explanation	Week 1-10: Data analysis from multiple hands-on experiments Seeds/pendulums/raisin tonic/magnets/food car/electricity
Communicate explanations and investigations	Week 1-10: Presenting findings to classmates from multiple hands-on experiments. Seeds/pendulums/raisin tonic/magnets/food car/electricity Project presentations
Fundamental Understandings About Scientific Inquiry: K-4 (NRC, 2000)	
Inquiry investigation involves asking and answering questions and comparing answers with what scientists already know.	Week 1-10: Design/execution/data gathering/data analysis on the multiple experiments
Scientists use different kinds of investigations depending upon what questions they are trying to answer.	Week 1-10: Multiple experimental designs Seeds/pendulums/raisin tonic/magnets/food car/electricity
Simple instruments provide more information than scientists obtain using only their senses.	Week 1-10: Multiple experimental designs Seeds/pendulums/raisin tonic/magnets/food car/electricity
Scientists develop explanations using observations (evidence) and what they already know (inquiry knowledge).	Week 1-10: Data gathering, research and journal entries and data analysis.
Scientists make results of their investigations public to enable others to repeat the investigations	Week 1-10: Sharing data with peers in other groups
Scientists review and ask questions about results of other scientists' work	Dialog with the instructors and peers on findings and explanations

Both instructors stated that they used the same syllabus and the same course materials.

The syllabus was developed by the senior instructor teaching the science methods course.

He indicated that he had developed the syllabus based on the NSES recommendation as articulated by the response below:

> I used the teaching standards in developing the syllabi. I also used the MO STEP standards they are specified……. uh on that the summary report from their field experiences they are to address what they've learned during their field experience and connect it to the teaching standards (P2).

Examination of the course materials (TDP 480) outlining the experimental activities shows that the instructors initiated teaching about inquiry starting with structured (provided step-by-step direction, Colburn, 2000) partial (one or more of the essential features of inquiry were missing, NRC, 2000) inquiries where preservice teachers were given step by step directions for an investigation in their handouts, to guided (teacher provides only the materials and problem to investigate, Colburn,2000), partial inquiries where the preservice teachers were provided materials but were required to design their own investigation, and finally to full (encompasses all the essential features of classroom inquiry, NRC, 2000) and more open (similar to guided but students formulate their own problem to investigate, NRC, 2000; Colburn, 2000) inquiries where preservice teachers were challenged with a probing question and were required to investigate the question by designing an experiment, executing the experiment, collecting data, evaluating data , reporting their findings, and finally sharing their conclusions with their peers. Use of structured (Colburn, 2000) and guided inquiries is consistent with recommendations in literature that "unless students have opportunities to receive guidance as they investigate phenomena, they will not develop the abilities to perform inquiry" (Volkmann et al., 2005, p.866). Also, the use of multiple types of inquiries (structured versus guided versus open inquiry and partial versus full inquiry) by the science methods instructors is consistent with the recommendations of the Standards that students should have “opportunities to participate in all types of inquiries in the course of their science learning” (NRC, 2000, p.30).

Structured and guided inquiries were used to develop abilities and concepts in inquiry. Most activities started out with structured or guided partial inquiries and then progressed to guided, full inquiries. For example in the pendulum experiment preservice teachers were given step by step directions on how to construct a pendulum using a string, a paper clip and a washer and were asked to make it swing. They were then asked to record the number of times the pendulum swung, how they accomplished it, to repeat their experiment and record the number of swings it made in 20 seconds, thus this was a structured inquiry. An extension of this experiment asked preservice teachers to identify the variables that might affect the swing rate and to record their results for changes in each variable keeping everything else constant. This was a guided, partial inquiry because preservice teachers were engaged with a question but were not asked to evaluate their results in light of what is already known.

Similarly, in an experiment on magnetism students were given a magnet and different materials and asked to perform directed experiments, make and record their observations, and report their findings. This first part of the experiment started out as a structured inquiry as it provided preservice teachers step by step directions on what to do. For example, the preservice teachers initially ascertained what happens when certain materials are brought near a magnet. However, in an extension of this activity preservice were asked to repeat the experiment with different materials or under different conditions such as under water, and asked to predict and explain the change in the outcome. This activity was geared towards developing their cognitive analytical thinking skills and showed preservice teachers that learning science involves both hands-on and minds-on activities as articulated by the NSES. This activity transitioned from a structured inquiry to a guided, full inquiry as the preservice teachers were required to design their experiment and evaluate their explanation in light of what was already known.

The electricity experiment was a guided, partial inquiry because the instructors assigned the experiment and provided the materials for the experiment. Specifically, the instructors left a few materials such as a battery, bulb, a strip of aluminum on each student station and asked preservice teachers to design an electric circuit to light a bulb. The electricity experiment also had extension activities that required preservice teachers to design further experiments using the materials provided to answer probing questions or to predict an outcome of change in the findings as result of change in experimental design. Therefore, this experiment also went from guided, partial to a guided, full inquiry.

All three activities cited above were structured or guided inquiries designed to specifically teach preservice teachers skills associated with observation, recording data, developing findings based on data, and reporting their results. However, the extension activities required preservice teachers to explore the answer to scientifically oriented questions. In all three extension activities preservice teachers were not required to "evaluate their explanations in light of alternate explanations particularly those reflecting scientific understanding" (NRC, 2000, p.25). Therefore, the extension activities were guided, partial inquiries. According to the NRC commentary on the NSES (NRC, 2000), full inquiries include all five essential features of classroom inquiry outlined by the standards (NRC, 1996) and if an inquiry is missing one of these five essential features, it is considered a partial inquiry. The above activities, and others like these, were geared to develop and reinforce abilities and concepts necessary to do inquiry.

The seed experiment started out with a structured inquiry, progressed to a guided, partial inquiry with the first set of extension activities, then progressed to guided, full inquiry and culminated with activity designed as full, and more open inquiry. The seed experiments lasted from weeks 1-10. The culmination activity of the seed experiment was a full inquiry as it encompassed all five essential features of classroom inquiry outlined by the Standards and the instructor did not provide guidance. For example, in the culmination activity the preservice teachers were engaged to explore by scientifically oriented questions raised by their instructor, were required to design and perform experiments (outside their class hours) to answer at least four of the ten scientifically oriented questions noted in their handout, collect data or evidence, formulate explanations of their findings based on evidence, evaluate their explanations in light of what they had learned about seed germination through reading of books or journal articles, justify their explanations from their readings, summarize their experiments and findings in a report, and finally to communicate their findings to the class. Thus all five essential features identified by the NSES for classroom inquiry, were integrated into this activity. During the culminating seed extension activity very little to no guidance was provided by the instructor, therefore this activity was more on the open side. According to the NSES, inquiry-based teaching can vary in the “amount of structure, guidance, and coaching the teacher provides for students engaged in inquiry” (NRC, 2000) and the most open form of inquiry-based teaching and learning occurs when students’ carry out an inquiry without any guidance. However the Standards also point out that students rarely have the abilities to begin with open inquiries (NRC, 2000). This is especially true of elementary students. Therefore most of the activities that the elementary preservice teachers in this study were involved in were guided, partial or full inquiries; only the seed activity was a full, open inquiry. Table 8 is an example of some of the activities executed in the methods class and the corresponding categories of inquiry.

Table 7: Activities and Inquiry Types

Activity Type	Types of Inquiries			
	Structured/Partial	Guided/Partial	Guided/Full	Open/Full
Pendulum				
Stage I	X			
Stage II		X		
Magnetism				
Stage I	X			
Stage II		X		
Electricity				
Stage I		X		
Stage II			X	
Seeds				
Stage I	X			
Stage II		X		
Stage III			X	
Culminating				X

According to the instructors, the seed activity was extremely important in giving the preservice teachers hands-on and minds-on experience and in developing their understanding about what constitutes an inquiry, how an inquiry is executed, and the value of inquiry to learning and teaching science. It also taught preservice teachers how scientifically oriented questions from the teacher can get students engaged in investigations, data collection, recording findings, and evaluating results. The instructors also pointed out that the seed experiment with its multiple extension activities taught preservice teachers how initial investigations done by students can raise further student questions which can then trigger further student investigations.

Examination of course materials also shows that classroom time was devoted to the understanding and use of operational questions for initiating student inquiries and to teaching effective questioning strategies. For example, the course material for TDP 480 included a section on ‘Effective Questioning Strategies’. This section was geared to teach preservice teachers how to ask questions. There was also a section on ‘Operational Questions’. This section dealt with teaching preservice teachers how to formulate scientifically oriented questions to initiate student questions or inquiries. An operational question is defined in this handout as a question that states or implies what must be done with the science materials to obtain an answer to the question. An operational question excludes questions beginning with “why”. The text of this handout explains that these questions are designed to help students ask more productive questions and explains that students must ask questions that lead them back to doing something with the materials in order to derive answers. The handout on ‘Effective Questioning Strategies’ outlines ten steps on how questions can be used to promote and facilitate inquiries. The use of Operational Questions to trigger student investigations and effective questioning strategies were demonstrated, in the science methods course, through multiple inquiry-based activities outlined above. The sub question utilized to analyze the interview

(delivered curriculum)data was as follows:

Q 2: What teaching strategies were used to develop abilities and understanding of preservice teachers for science as inquiry as articulated by the NSES?

Interview Transcripts Analysis

Multiple teaching strategies were used by the science methods instructors to integrate the NSES recommendations for teaching and learning science as inquiry. These include the following:

1. Designing multiple inquiry-based experiences
2. Guiding and focusing student inquiries instead of lecturing
3. The use of instructional models (5E) encompassing the five essential features of classroom inquiry outlined by the NSES.
4. Use of operational, scientifically oriented questions to initiate student investigations
5. Classroom discussions on inquiry-based science teaching and learning.
6. Development of lesson plans and curriculum integrating NSES recommendations for teaching science as inquiry.
7. Use of science notebooks for data collection and reflection.
8. Evaluation of instructional material for suitability to teach science as inquiry.
9. Assessment strategies to evaluate understanding

Multiple inquiry-based activities. The first teaching strategy used by the instructors to teach inquiry, inquiry-based pedagogy, and to integrate the NSES recommendations was to provide preservice teachers multiple inquiry-based experiences spanning from partial to full inquiries as recommended by the NSES (NRC, 2000). When I asked the science methods instructors to elaborate on how they taught inquiry to preservice teachers, they both stated that this was done by having the preservice teachers actively involved in multiple inquiry-based activities. The graduate student teaching instructor compared inquiries to working in the constructivists environment since both forms of learning are student centered as indicated by the response below:

> Well they experienced it in their seed project and they experienced it in their other investigations and I think it's uh….a lot of things we talk about is uh student centered versus teacher centered you know and constructivism. I think I try to incorporate all those into one kind of understanding it's a matrix between constructivism, 5E and inquiry there's building on students' prior knowledge, letting them construct their own knowledge which ties in with inquiry and answering their own questions (P1)

The instructor pointed out that even though the focus of all investigations was inquiry, the preservice teachers seemed to adopt and take a liking to the 5E instructional model as articulated below:

> That's the focus of all the investigations. But you have to keep coming back to it you know, and uh I don't know why its I don't know why its difficult but like I said they kind of adopted the 5E more readily than inquiry but you know you just keep going back to it and I think its more of how to be a more student centered teacher is what we're working on and that comes with beliefs and beliefs are kind of hard to change, but I think their seeing the benefit of that you know and but I warn them too that this style of teaching this approach to teaching is difficult for beginning teachers because there's always the issue of classroom management. (P1).

It is interesting to note from the above response that the graduate student instructor is differentiating between the 5E instructional model and inquiry even though this model meets all the five essential features of classroom inquiry outlined by the NSES. It is also interesting to note that the graduate student instructor felt that teaching inquiry-based science might present classroom challenges to new elementary teachers teaching science and accordingly cautioned the preservice teachers about this. His apprehension about implementation of inquiry by new teachers is similar to a report in literature where preservice teachers when asked to implement inquiry-based lessons in their field experience, expressed anxiety about difficulties maintaining control of students during open inquiries (Hayes, 2002).

An interesting finding of this study was that the instructor indicated that most of the preservice teachers struggled with the constructivist approach to learning science whereby students construct their own learning through active involvement. Specifically, they indicated that preservice teachers were taught inquiry through guided, hands on activities, however during open inquiries when there was little or no guidance given by the instructors, the preservice teachers, when left on their own to construct their learning, struggled with the execution of the activity. The response below by the graduate student instructor indicates that he picked up on the preservice teachers' struggle/frustration of learning science in a constructivist environment:

> "Learning by doing, active learning. They were….we really used open inquiry in the seed project and they struggled (laughs), and they struggled pretty good "(P1)

The instructor emphasized that even though working with inquiries that were more on the open side was frustrating to the preservice teachers, they refrained from lecturing as they wanted the preservice teachers to understand and learn inquiry by experiencing it as articulated by the response below:

> Predominantly they had to experience it. So rather than telling them they experience it first hand, and then discussion afterwards which is frustrating for them. But I have a philosophical concern that you don't lecture on how to do inquiry. So I would say that they are doing hands-on activities 60 to 70 percent of the instructional time (P2).

This teaching approach where the instructor allowed preservice teachers to learn through open inquiries is consistent with teaching students how scientists operate and consistent with Piaget's theory (1975) and the constructivist paradigm on human learning (NRC, 2000) and with the NSES recommendations for inquiry. Specifically, this approach to teaching is aligned with the NSES as the Standards point out that experiences that vary in openness are needed to develop the abilities necessary to do inquiry and that "guided inquiry can best focus learning on the development of particular science concepts" while a "more open inquiry will afford the best opportunities for cognitive development and scientific reasoning" (NRC, 2000, p.30).

Interestingly, the instructors pointed out that though the students were initially frustrated, their written journals and reflections indicated that the inquiry-based teaching and learning was effective in teaching them the concept of what constitutes inquiry. This is implied in the response below in which the instructor points out that the students who were interested in science were showing their understanding of inquiry as articulated in the response below:

> Uh but you see in their journals and their reflections that some of them are really there, I mean those that were interested in science were there, you know and it was very impressive, and you can kind of tell those maybe not so much but through the other more you know uh smaller classroom investigations you know they got to be uh better at investigating (P1).

The seed activity design is an example of how projects can be designed to extend beyond the processes of science to engage students in a full complement of thinking and learning which is consistent with the recommendations of NSES for developing fundamental understanding about inquiry. It is important to point out that as part of this seed project, the preservice teachers were also asked to integrate other subjects such as mathematics (e.g. measurements etc.), fine arts (drawings etc) or language arts (written reports etc) into their activity.

Guiding and focusing inquiries. The second teaching strategy used by the instructors to inculcate the understanding of inquiry in preservice teachers was to guide and focus student inquiries. Specifically, the instructors indicated that they facilitated inquiries by involving students in inquiry-based projects and by requiring the use of science notebooks for recording data and observations as indicated by his response below:

> I'm going to refer to the teaching standards of the National Science Education that you organize using inquiry as the driver. It's organizing it in multiple approaches from the perspective that active learning and one of the ways I facilitated that was through the use of science notebooks and then using projects Uh, the way of encouraging students to develop understanding through higher order thinking skills, and modeling constructivism (P2).

Thus, the instructors indicated that rather than teaching to the text, they integrated recommendations of the NSES for teaching science using inquiry-based pedagogy by designing inquiry-based activities and by facilitating and focusing student inquiries. This teaching approach is consistent with the NSES teaching Standard B recommendations that teachers' of science guide and facilitate learning (NRC, 1996).The responses below indicate that the instructors stressed the importance of building on previous student knowledge, used learning stations, learning packets, questioning strategies, operational questions, and journals to teach inquiry:

> From a content perspective as well as from a teaching perspective I focused on inquiry. They had some at the start of the semester we did a learning cycle and that stressed prior knowledge and ways of accessing that. We had learning stations, learning packets, questioning strategies, operational questions, 4 question strategy (P2).

> We did…uh experiments did a lot of you know investigations, a seed project, the journaling was good, uh electricity and magnets they had had that in their physics for elementary teachers class but I think there was still room for learning. (P1)

It is interesting to note that the graduate student instructor acknowledged that even though some preservice teachers had been exposed to inquiry in their elementary education physics class, they still learned a lot about inquiry from the science methods class. This is consistent with reports in literature that science content for teachers has to be reinforced with learning how to teach (Darling- Hammond & Youngs, 2002).

5E learning cycle instructional model. The third instructional strategy used by the instructors to integrate the NSES recommendations for science as inquiry was the use of the Learning Cycle Instructional Model for teaching science. This instructional model is consistent with the five essential features of classroom inquiry (NRC, 2000) identified by the NSES for teaching and learning science using inquiry-based pedagogy. Their responses below indicate that the instructors focused on the learning cycle model, specifically the 5E instructional model, which is based on the constructivist approach to teaching and learning through inquiry:

"Well basically inquiry, the 5E. I think they uh kind of identified more with the 5E, but I think in their lessons that they presented uh they have pretty good understanding of inquiry uh" (P1).

The 5E instructional model used by the science methods instructors to model science instructional strategies has five learning phases: engagement, exploration, explanation, elaboration and evaluation. The 5E instructional model and its five learning phases are consistent with the five essential features of classroom inquiry articulated in the NSES for all grade levels. Table 4 (Chapter 2) shows similarities between the five phases of 5E Instructional Model and the five essential features for classroom inquiry outlined by the NSES while Table 5 (Chapter2) shows similarities between the 5E Instructional Model, the NSES teaching standard B, and expected student outcomes. The use of the 5E instructional model is consistent with the integration of NSES recommendations into the teaching strategies used by the instructors of the science methods course.

An important finding from the interview transcripts is that the instructors had also modeled the changing role of the science teacher. Specifically, they had demonstrated how the teacher becomes a facilitator rather than an instructor teaching to the text, when inquiry-based pedagogies are used to teach science as illustrated by the response below:

> From a content perspective as well as from a teaching perspective I focused on inquiry. They had some at the start of the semester we did a learning cycle and that stressed prior knowledge and ways of accessing that. We had learning stations, learning packets, questioning strategies, operational questions, 4 question strategy. Demonstrated teaching strategies as a facilitator and that is a new role that they have not encountered before (P2).

This modeling of the new facilitator role for teachers is consistent with the science classroom envisioned by the NSES where effective teachers function more as facilitators "continually creating opportunities that challenge students and promote inquiry by asking questions" (NRC, 1996, p.32).

Questioning strategies. The fourth teaching strategy used by the instructors to teach inquiry, was the use of operational, scientifically oriented questions to show preservice teachers' how to initiate an inquiry. Review of the course materials indicates that class discussions and assignments were made on the use of operational questions for initiating thinking from preservice teachers. The instructors also emphasized to the preservice teachers the importance of facilitating questions from students and allowing students to answer their own questions through investigations as indicated by the response below:

> Um one of the things that we focus on or that we focused on in class was questioning and I pointed out to them that uh you hear a lot of teachers questions, teachers question all the time but you don't listen to students questions and from those comes your investigations, your collection of data and your gathering of evidence to explain and communicating those ideas so I think their picking up on that. Uh whether they see it as a way science is done…you know as we went through the national standards hopefully they picked some of that up (mumbled),uh and its uh inquiry as a teaching strategy their coming to an awareness of that (P1)

The use of operational questions to trigger student investigations is consistent with the NSES Teaching Standard B recommendation that teachers of science orchestrate discourse among students about inquiry ideas and encourage curiosity, and that instructional activities of inquiry should engage students in identifying and shaping an understanding of the question under inquiry (NRC, 1996, p144).

In the science classroom envisioned by the Standards, effective teachers are expected to create opportunities that challenge students and promote inquiry by asking scientifically oriented, probing questions that spark student interest to follow through with an investigation. Consistent with this vision, one of the key competencies associated with understanding of inquiry emphasized in the science methods course syllabus, was the questioning strategies for engaging students in scientific inquiries. Accordingly, preservice teachers were taught in weeks 6 and 7 effective questioning strategies. Specifically, preservice teachers were taught how to formulate operational questions to engage students in investigations. The seed experiment was one example of operational questions that were raised by the instructors to engage the preservice teachers in investigations.

Classroom discussions. The fifth teaching strategy used by the instructors to integrate the recommendations of NSES for science as inquiry was use of classroom discussions on the NSES and its recommendations for teaching science as articulated in the response below:

> We reviewed the standards, National and State standards and it kind of encourages students when they see strand 7 and strand 8 inquiry and nature of science that they can incorporate into the lesson plans and then I think uh also uh we focused on what we're calling habits of mind uh which is probably more related to elementary science education. And the other thing we emphasized is the process skills and how these process skills can be used when they're reading books and stories to students. Probably need a little work on that cause their limited to uh prediction and uh maybe some observation, but you know there's a lot…..hopefully they'll get to see some really good teachers that know science and know how to read stories and incorporate those things so that….yeah I think their catching on (P1).

Preparation of lesson plans. The sixth instructional strategy used by the instructors was to have preservice teachers prepare lesson plans, as part of the science methods course requirement, for teaching science topics incorporating the NSES recommendations

> We reviewed the teaching standards most of that's besides inquiry and the nature of science uh we looked at those and I broke them up into groups and each group had to present that standard to the class. Uh, but still it's a spiral learning uh I went back to them again when they were writing their lesson plans because they had to include uh unifying concepts but they keep putting the teachers standards in there, but when we looked at them again and when you started revisiting it's kind of a you know you put it out there then you put it out there again you put out there again and I think their understanding of what these teaching standards are um is improving is increasing (P1)

The above response indicates that preservice teachers were taught how to develop lesson plans incorporating NSES recommendations for learning and teaching science through inquiry.

Use of science notebooks. The seventh strategy utilized for teaching inquiry was the use of science notebooks. Specifically, the instructors used the following text: *Science Notebooks, Writing About Inquiry, by Brian Campbell & Lori Fulton, Heinemann, Portsmouth, NH, 2003* to teach preservice teachers the use of science notebooks for recording data, reflections, and conclusions of inquiry investigations. This book was also used to teach the preservice teachers how to ask probing, open ended questions to initiate inquiry investigation or dialog on inquiry phenomenon within their classrooms. There were also assignments in this book that included reading about the NSES, reflection on data and how scientists use notebooks to document their work.

Evaluation of instructional material. An important part of teaching science through inquiry is to select instructional materials that might be beneficial in teaching science through inquiry. Also one of the expectations articulated in the NSES is that teachers of science be able to analyze instructional materials for its effectiveness to teach inquiry (NRC,1996). Therefore, the eighth strategy used by the instructors to incorporate the recommendations of the NSES for teaching science using inquiry was to have preservice teachers evaluate instructional material for suitability to teach science through inquiry. Examination of the course syllabus and the responses of the instructors on the interviews, indicates that preservice teachers were taught how to do this through assignments for evaluation of instruction materials available via the Internet as illustrated by the response below:

> I had them go out there, there is so much out there and available, I just kind of had them wander. But then we went through and they post their uh their resources and lesson plans on a discussion board on Blackboard, so students can look at it. Uh, and then we kind of go through and analyze these things and you know and I and so what I ask them to do is to look you know these kind of websites are informational, good information but they don't teach you how to teach so go find some sites that are more you know on the instructional basis and then analyze it and say oh, does this look like 5e, does this have inquiry in it. I think if they teach them how to identify those components of a good science lesson uh I think it came across in their lessons. And then their learning from others and their building on that and then the discussion and the reflection we have after each lesson uh kind of builds on that and you can see the lessons progressing and their quick they pick up on this stuff very readily (P1).

Interestingly, both instructors indicated that teaching preservice teachers how to assess the suitability of instructional material for teaching science through inquiry was the hardest aspect of their instruction. The instructors indicate that this was because of the limited science content background of the elementary preservice teachers as articulated in the response below:

> That's the hardest part involved with that because frequently they don't have a background understanding of content. For some of them they're still at the point you teach process separate from content even thought the standards says that these need to be merged. So they're more comfortable from a process perspective but trying to integrate…uh we spent some time dealing with clarifying the standards, then uh from uh I think its page 29 the Inquiry National Science Education Standards we looked at how the variation of structure from a teacher as well as a student perspective for those five attributes (P2).

Thus, responses above indicate that both instructors were apprehensive about the ability of the preservice teachers to effectively evaluate instructional material to teach inquiry-based science given the limited pedagogical content knowledge and the knowledge of science content both of which are required for assessment of instructional materials.

The instructors indicated that the teaching strategies used by them were geared to helping preservice teachers develop confidence to teach science and specifically to use inquiry-based pedagogies and group activities (where students can learn from each other). The responses below indicate how the group members helped one another during inquiry-based activities such as preparation of lesson plans as illustrated below:

> I think that comes with these lessons and their able to do it cooperatively you know so they can bounce back and stuff. And I think their getting better and I'm having each group of students evaluate the other groups' lessons and those they get that feedback and their getting better at providing you know not just positive feedback but you know ways to improve and we've discussed that and I think uh getting up their and working with the class and getting that experience hopefully that'll help I don't know….that is yet to be seen (P1)

> …..some of them have had very bad experiences beforehand and as they do things especially the things which are more student oriented, by that I mean elementary student packets, that they can see ways of doing it. I had a couple of people in field experience observing a lesson on pendulums and because they had already done pendulum activities they were able to help the children okay, but if they had had a lot more field experiences because this is the semester in which students in grade 5 are doing experimental design, they would have been able to see or have been able to share a lot more experiences. So even though they didn't observe directly they would have heard others (P2)

The above responses indicate the one of the ways the instructors helped students develop confidence in doing inquiries was by having them work in groups and provide feed back to each other. Thus, one of the ways in which the instructors developed preservice teachers' confidence to teach science was through social interaction.

An interesting finding from the interview transcripts was that the instructors were apprehensive about how realistic it is to expect preservice teachers graduating armed with new inquiry-based instructional strategies to be able to use them in actual practice as indicated by the response below:

> … but I warn them too that this style of teaching this approach to teaching is difficult for beginning teachers because there's always the issue of classroom management. So I tell them that too. I say we're not expecting you to meet these MO STEP standards the first year, five or six years'

> maybe. First thing you need to do is establish your rapport with the class and get your classroom management skills down (P1)

> …I think we have uh unrealistic expectations (laughs) that student teachers or first year teachers are going to go in and start doing all this magic stuff or this new stuff they learned in a culture that doesn't support that. But hopefully you know over time these things and their experience in class will come back and you know be science advocates also (P1)

As indicated by the above response, the graduate student instructor felt that being first year teachers, it might be hard for the preservice teachers to implement inquiry-based instructional strategies in their classrooms given the current set-up of the schools and the effort and time required to plan and implement inquiry and the possible classroom management issues that might arise due to the student directed nature of inquiry-based activities. This same apprehension was not voiced by the second instructor during his interview.

Assessment strategies. An important part of evaluating student understanding of any subject is to have relevant assessment strategies. The NSES document points out that assessments in the context of inquiry, "need to gauge the progress of students in achieving two major learning outcomes of inquiry-based science teaching: abilities to perform inquiry, and understandings about inquiry" (NRC, 2000, p. 75). Therefore, the next sub question used to analyze the data was as follows:

Q3: What type of assessment strategies were used to assess preservice teacher' understanding of abilities required to conduct inquiry and their understanding about inquiry as articulated in the NSES for grades K-4?

The instructors indicated that they used formative and summative assessments. Formative assessments were done based on participation in class discussions and observations of preservice teachers during experimental inquiries. Summative assessments were done using scoring guides for each activity, including written reports, preservice teachers' reflections in their journals, science notebooks, presentations etc., and through assessments of inquiry-based lesson plans and inquiry-based science curriculums prepared by the preservice teachers during the course of the semester. The following responses indicate that the instructors used class presentations, and curriculum reports to assess student understanding:

"Well one of the ways in which I judged that this semester is when they did their curriculum reports. "(P2)

"Most of the groups chose to incorporate an active component for their peers and they were modeling aspects of how to go about providing inquiry-based instruction, how to deal with individual groups etc "(P2)

The graduate student instructor indicated that he conducted formative assessments to assess understanding of inquiry through the use of information presented by the preservice teachers on whiteboards as articulated below:

> We used extensive amount of whiteboards. And one time there was an assignment and there was one group who wanted to use the whiteboard to do their project with, okay which I had not thought about but that was perfectly alright. I think from that perspective they were seeing different things that utilized their strengths plus seeing diverse orientations." (P1)

The final assessment of preservice teachers' understanding of science as inquiry as articulated in the NSES was done through a culminating final exam activity that required preservice teachers to develop a reflective portfolio of supporting evidence indicating each preservice teacher's professional understanding and growth. Portfolio required the incorporation of the competency areas such as: competency in standards and elementary science; attributes for successful science teaching; hands-on science instructional strategies/models; and attributes for grades K-6 curricula, which promote science learning through inquiry.

Section-I Summary

Examination of the course syllabus, the course materials and handouts shows that the elementary science methods course at UMC was designed to involve preservice teachers in multiple inquiry-based activities to teach them the abilities necessary to conduct inquiries and to give them understanding about inquiry and how scientists work. Further, the syllabus shows that the inquiry-based activities designed to take students from structured or guided, partial inquiries where the instructors provided directions to open, full inquiries which required preservice teachers to execute experiments, make observations, collect data, report findings, develop explanations from their findings in light of what was known, and share their explanations with the class. Preservice teachers struggled with open inquiries due to the lack of structure and guidance provided by the instructors. Use of open inquiries is consistent with the NSES assertion that a more "open inquiry will afford the best opportunities for cognitive development and scientific reasoning" (NRC, 2000, p.30). This transition from structured to guided, partial or full inquiries to open, full inquiries is consistent with the recommendations of the NSES that students should have "opportunities to participate in all types of inquiries in the course of their science learning" (NRC, 2000, p.30).

The science methods course syllabus was also geared towards teaching preservice teachers the use of operational questions and effective questioning strategies required to initiate student inquiries. This is consistent with the recommendations of the NSES assertion that effective science teachers “continually create opportunities that challenge students and promote inquiry by asking questions (NRC, 1996, p. 33). Also, assessment strategies, formative and summative, used in the course were designed to teach elementary preservice teachers how to evaluate students’ knowledge of abilities necessary to conduct inquiry, and understanding of concepts about scientific inquiry. This form of assessment which evaluates students’ understanding rather than their memorization of facts, is consistent with the NSES recommendation that in the context of inquiry, assessments need to gauge “the progress of students in achieving the three major learning outcomes of inquiry-based science teaching: conceptual understandings in science, abilities to perform scientific inquiry, and understanding of inquiry” (NRC, 2000, p. 75). Thus, the intended (course syllabus) science methods course curriculum at UMC for winter 2006 was consistent with the recommendations of the NSES for teaching fundamental abilities necessary to conduct scientific inquiry, the fundamental concepts about scientific inquiry and how to teach using inquiry.

The delivered (interview transcripts) science methods course curriculum, at UMC for winter 2006, or the teaching strategies used to teach inquiry to the preservice teachers was also consistent with the recommendations of the NSES for teaching science as inquiry. For example, the 5E Learning Cycle Instructional Model used by the science methods instructors to teach science through inquiry encompasses all five essential features of classroom inquiry outlined by the NSES. Similarly, the instructors’ use of operational, scientifically oriented questions to trigger preservice teachers’ investigations and the guiding and facilitation done by the instructors to focus inquiries are all consistent with the recommendations of the NSES teaching standard B that teachers of science facilitate student learning by focusing and supporting inquiries. Also, the organization and selection of student activities by the science methods instructors, was specifically geared to the integration of NSES recommendations for science as inquiry and to developing student abilities for conducting inquiry and understanding of inquiry. The instructors had designed numerous projects to actively involve students in inquiries which spanned from structured or guided inquiries, where students were guided through the activity, learning skills and vocabulary associated with inquiry; to open, full inquiries where students independently thought through the operational question asked, designed and assembled equipment to investigate and the answer to the operational question, and open inquiries which were geared to developing preservice teachers cognitive abilities in science. These teaching strategies are consistent with the NSES recommendation that students be exposed to all types of inquiries during their learning of science (NRC, 2000).

Thus, the teaching strategies used in the science methods course were designed to teach preservice teachers how to focus and support students through inquiry-based investigations, how to use inquiry-based activities to develop the abilities and concepts necessary to do science as inquiry, and how to facilitate the understanding about inquiry by active involvement of students in conducting guided or open inquiries which is consistent with the NSES recommendations for teaching science through inquiry (NRC, 1996). The assertion that emerged from the evaluation of the syllabus and the interview transcripts is:

> Multiple inquiry-based science teaching and learning strategies are used to integrate the National Science Education Standards recommendations for doing science through inquiry in the science methods course at the University of Missouri- Columbia.

This assertion directly supports research question 1 namely:

> In what ways are the inquiry-based science teaching and learning strategies recommended by the National Science Education Standards integrated/emphasized in the science methods course at the University of Missouri- Columbia?

Thus the data successfully answered the first question that guided this research study.

Section-II-Analysis of Data in Support of Research Question 2

This section contains analysis of data in support of research question 2, namely:

Research Question 2:

What do elementary preservice teachers report regarding their understanding of inquiry and inquiry-based science pedagogy after concurrently completing the science methods course along with the science field experience at the University of Missouri- Columbia? The categories of meaning used to guide the analysis of data relating to research question 2 are outlined below:

1. Previous exposure to inquiry and inquiry-based learning.
2. Exposure inquiry-based pedagogy through the science methods course.
3. Exposure to inquiry-based pedagogy through the science field experience.
4. Influence of science methods course on preservice teachers' understanding of inquiry.
5. Influence of science methods and the science field experience on preservice teachers' understanding of inquiry-based pedagogies to students' learning of science.

6. Preservice teachers' reflections on learning science through inquiry
7. Personal science pedagogy concept development.
8. Understanding of the NSES recommendations for teaching and learning science through inquiry for grades K-4.

Section II contains findings from analysis of data from the preservice teachers' reflections in the focus groups (received curriculum) which are organized under the sub questions developed from the above categories.

Prior Exposure to Inquiry

In order to understand the contribution of science methods course and the science field experience at UMC for teaching inquiry and inquiry-based pedagogy to elementary preservice teachers, the following sub question was used to ascertain preservice teachers' exposure to inquiry-based pedagogy prior to the science methods course:

Q1: What do preservice teachers report regarding their exposure to inquiry and inquiry-based pedagogy prior to the science methods course and science field experience at UMC?

When preservice teachers were asked how the teaching strategies used and taught in the science methods course compared with their previous exposure/experience of inquiry, most of the preservice teachers indicated that they had not been exposed to inquiry-based instruction prior to the science methods course and science field experience at UMC as illustrated by the responses below:

"I had not done inquiry till this class" (G3-S2)

"Yeah, I really didn't know much about it" (G4-S3)

"I had no idea" (G4-S1)

"I really had not even thought about what inquiry is." (G1-S1)

The above responses indicate that most preservice teachers had no prior exposure to inquiry-based science teaching strategies. There were a few preservice teachers who had some knowledge about the purpose of inquiry for scientific work but had not made connections to the use of inquiry to teaching and learning science as typified by the response below:

“I knew that scientists explore things, but I did not know that we too can be like them, in a small sort of way: (G1-S5)

Majority of the preservice teachers reported receiving exposure to inquiry and inquiry-based pedagogy through the science methods course and science field experience as stated below:

“Didn’t know what inquiry was. Not how we were taught. Didn’t think it would work, but saw it in here and field (G1-S3”).

“Through this class we not only got exposed to the word inquiry but also how to go about it” (G2-S6).

“Well since it’s just something we just started elaborating on we really didn’t have much of a view beforehand. So this class has made it more complete because we’ve learned about it” (G3-3)

In short, the preservice teachers reported that inquiry was emphasized through the science methods course and the science field experience as stated below:

“This semester just hammered in inquiry into our heads (G3-S4)”.

“He made us inquire and like conduct our own investigations all semester long” (G4-S1).

By using the word ‘hammered’ preservice teachers are communicating the extensive exposure they received through multiple inquiry-based activities through the methods course. Some preservice teachers reported exposure to inquiry form of instruction through their mathematics, science or physics courses as stated in the responses below:

"I think what I learned about inquiry came a lot from the math class and from the physics class there again" (G4-S3).

"I had done some hands on activities in some science classes, but did not relate them to inquiry" (G3-S6).

The preservice teachers who reported previous exposure to inquiry through other courses, considered exposure to inquiry-based pedagogies through the science methods course as a reinforcement of the inquiry form of instruction as articulated in the responses below:

"I didn't come in here and say oh wait I thought inquiry was something else. So I think it was consistent with what I had been exposed to" (G5-S1)

"I had some idea about inquiry from the physics class, this class reinforced it "(G5-S5)

This above finding is consistent with the observation of the graduate student instructor that for some preservice teachers who had been exposed to inquiry form of teaching in their education physics course the methods course was reinforcement.

It is interesting to note that some preservice teachers had reported that they made connections to their previous exposure to the inquiry-based instruction through science content only after they experienced inquiry through the science methods course. These preservice teachers indicated that even though the inquiry-based instruction had been used in some of their previous science content courses, they had not realized that they were learning inquiry or that inquiry was an important instructional tool for teaching science as indicated by the responses below:

> ---Like we had done some inquiry in my physics class for education majors but we didn't really know what it was called. And like we've heard the term thrown around before but never really applied it to teaching or how we could possibly teach that way (G2-S5)
>
> And before a lot of times in science like you do an experiment but its not necessarily through the motions of conducting inquiry but its not open ended, and now you see how like to make it open ended and like you actually find something out (G4-S6)

These responses indicates that even though inquiry-based pedagogy was used in the education physics and mathematics course at UMC, the preservice teachers did not relate those teaching strategies to inquiry as they were not emphasized as inquiry-based in the content courses. The use of inquiry to teach science content is consistent with reports in literature, that some educators are developing and using inquiry-based science content courses to improve preservice teachers' understanding of science (Zembal-Saul et.al. 2000; Hudson, 2004; Jarvis et. al., 2001).

Thus, the majority of the preservice teachers reported not being exposed to inquiry-based teaching strategies prior to the science methods course. Those who were exposed to inquiry-based instruction in their math, science or physics class did not recognize the instructional strategies as being inquiry-based but drew connections to inquiry only after inquiry and inquiry-based instructional strategies were emphasized in the science methods course.

In order to evaluate contribution of the science methods course and science field experience to learning about inquiry and how to teach science through inquiry, the following sub question was analyzed:

Q2: What did preservice teachers report regarding their experiences of learning inquiry and inquiry-based pedagogy from the science methods course and the science field experience?

Exposure to Inquiry through the Science Methods Course

There was concurrence amongst preservice teachers that the science methods course had helped them understand what is meant by inquiry as reflected in their responses below:

“Definitely I have a better understanding of inquiry after this course (G4-S5)

I did not know anything about inquiry. Now I know that inquiry means to dig deep and find out what is going on “(G1-S6)

“Up until now I always thought that science involves experiments, but now I know that it could also involve literature search etc “(G1-S4)

“Having gone through this course I now understand what inquiry investigation involves. Before this I had no idea “(G3-S1)

Preservice teachers reported that their learning about inquiry was facilitated through their involvement in multiple inquiry-based activities throughout the science methods course as illustrated by the following examples:

> ---and for like electricity we would make circuits and for the circuits we would see which circuit would light up the light bulb and if we had a complete circuit would it light up two light bulbs. (G2-S1)
>
> --I guess like when working with electricity stuff you kind of realized I don’t know like how a light works, like you usually take things for granted…like got to discover like how things work I guess. Cause also during the electricity we wrote down like what things required electricity and what we used and so like what happen if there (Consensus uh huh, yeah) wasn’t electricity because you know you wrote down like well I watched TV and yeah like take a shower (G2-S1)

“-- Magnets experiment- We had to determine on our own what kinds of materials we had, which ones were magnetic and which ones were not?” (G1-S5)

The above responses are examples of the types of inquiry-based activities that the preservice teachers were involved in. Specifically these activities taught preservice teachers that they must design experiments using materials supplied to answer a scientifically oriented question posed by the instructor and that making observations, recording data, and reporting results, are all part of the inquiry process. The responses below indicate that preservice teachers’ were presented with materials and were expected to design an inquiry to answer a scientifically oriented question. They were taught the importance of collecting evidence, developing evidence-based explanations and justifying their explanations as articulated below:

> Batteries and lights experiment- We had to figure out how to create circuits, and how to make a light bulb shine. At the end of the experiment we compared the circuits created by everyone and discussed why certain ones worked and others did not (G1-S1)

“-- We used like vinegar and the popcorn kernels and raisins to see why some of them bounced up and down. And we had to write operational definition of what was happening “(G5-S5)

The above responses indicate the preservice teachers learned to use equipment, tools and materials to design experiments, to collect data, make observations, note down their findings and to explain their explanations. These are some of the abilities and competencies outlined in the Standards for conducting and understanding inquiry. Defending their findings and explanations with their peers is also consistent with the recommendations of the Standards for developing cognitive abilities or understanding about scientific inquiry.

Preservice teachers also reported that their comfort with using inquiry developed as a result of their involvement in multiple inquiry-based investigations through the science methods as stated below:

"Yeah, and we did it so much that I'm just a lot more comfortable with it. Like if someone just told me what it is I would have been like okay but how do I do that? "(G4-S3)

"It exposed us to so many different investigations that now at least I am more comfortable with what inquiry is" (G3-S2)

One activity that stood out from the preservice teachers' reflections in the focus groups was the set of experiments they did to study the germination of seeds. Review of course materials indicated that the seed experiments were triggered by ten operational questions where each preservice teacher was required to answer at least four of these questions through design of inquiry investigations. These sets of experiments represented open, full inquiries as defined by the NSES and were designed to teach preservice teachers how to conduct inquiries and what constitutes an inquiry. Most dialog among preservice teachers in the focus groups occurred on this project as indicated by the responses below:

> Seeds- We grew seeds and collected growth data for 5 weeks. We had to anticipate or predict and question what would happen over time. We kept a journal with the data in it. At the end of the five week we compared our prediction with what we had observed and noted down. We were then required to raise some extension questions and explain what could be done to further examine the growth of seeds. Integration was done through exchange of ideas (G1-S3)
>
> We like grew seeds at home and um had our own seed journals and recorded our observations and we were able to do drawings or um apply it to other subjects or just compare the different plants or elements that we decided to explore (G2-S3)

> --And back to the seeds investigation, one of the things that we were required to do was they gave us kind of a list of different options of experiments that we could do with our seeds for instance just like grow it in water with a seed in there, not watering your plant, watering with red food coloring, um a bunch of different things, like grow it in coffee beans, or not grow it in the sun and like grow it in the dark (G3-S2)

This inquiry-based activity was important in that it exposed them to the open, full inquiry as defined by the Standards. Specifically, in this activity they were engaged by scientifically oriented questions, learned to give priority to evidence which they used to develop explanation of the phenomenon they were observing, and were required to report their findings in terms of what they had learned and what was already known about germination of seeds. Therefore this inquiry took them through all the five essential features for classroom inquiry outlined by the Standards. In addition, they were given very little guidance in this activity as it was geared to developing their cognitive thinking abilities.

Preservice teachers' responses also indicate that in addition to using operational questions, to trigger preservice teachers' curiosity, the instructors also presented discrepant events to the preservice teachers and left them on their own to figure out what was going on. For example, the instructor left a 'glob' of material on each work station. Preservice teachers were expected to observe, identify the 'glob' and were required to report their findings and explanation to the class as articulated in the response below:

> There was some mysterious stuff on the table the first day we came into class. We had to record what it felt like and how it moved. We had to figure out the properties and describe it. It was really cornstarch and water and we had to use our senses and touch it to find out what it was. Our professor would not tell us any thing, he made it exciting by requiring us to identify the mysterious substance (G1-S6)

The responses above indicate that preservice teachers were involved in multiple inquiry-based activities in the science methods course which were geared to teaching them abilities required to conduct inquiry, the conceptual understanding about what constitutes inquiry and how to ask scientifically oriented questions or present discrepant events to trigger student curiosity to investigate. These multiple inquiry-based activities provided preservice teachers' exposure to inquiries ranging from structured to guided (partial to full) to open, full inquiries. This finding is consistent with the findings from the analysis of science methods course syllabus and transcripts of interviews with the instructors that inquiry-based learning and teaching strategies consistent with the recommendations of the NSES were taught in the science methods course through active participation of preservice teachers in inquiry-based activities. These findings indicate an alignment of the received curriculum with the intended and the delivered curriculum presented in section I of this chapter. Thus, the data shows that preservice teachers received extensive exposure to inquiry-based learning through the science methods course which helped them develop the abilities required to conduct inquiry and understanding about concepts relating to classroom inquires.

Contribution of the Science Methods Course to Learning Inquiry-Based Pedagogy

Regarding the contribution of the science methods course to teach preservice teachers how to teach science through inquiry, most preservice teachers reported that the science methods course provided good exposure to inquiry-based pedagogy to teach science. Specifically their reflections from the focus groups indicate that they were exposed to different instructional strategies that helped them understand inquiry and teaching science through inquiry such as: use of multiple inquiry-based activities to develop student abilities to conduct inquiries, use of operational, scientifically oriented questions to trigger student questions and further investigations, evaluation of science instructional material and science curriculums for suitability to teach science through inquiry, preparation of inquiry-based lesson plans, and teaching inquiry-based lessons. Preservice teachers reported that preparation and teaching of inquiry-based lesson plans was one of the main ways in which they learned how to teach science through inquiry as illustrated by the responses below:

> ---I think it also helped too that we all have to teach inquiry-based lessons, and so I know at least for me like actually teaching and writing my own lesson like now I know what it's supposed to be like. (Agreement uh huh, yeah) (G2-S1)
> Also preparing inquiry-based lesson plans forced us to think more about what inquiry. This class made me comfortable with teaching science (G3-S2)
>
> ---Well it has also been more like he's wanted like he's used inquiry to help us form this like knowledge of what inquiry is like. He's let us question things and by like actually doing it then we've like constructed this knowledge of what an inquiry-based lesson looks like. So we've learned by actually doing (G2-S3)
>
> "We taught 1 ½ hour lesson using inquiry in the methods course. "(G1-S1)

Thus, preparation of inquiry-based lesson plans was helpful for preservice teachers in learning how to teach science through inquiry. Preservice teachers reported that the science methods instructors did a good job of drilling into their heads that inquiry-based instruction was a good way to teach science as articulated below:

> Well I think pretty much we got it grinded into our heads from our science teacher…INQUIRY, INQUIRY, INQUIRY (laughing) you should use it in your classrooms it's the best way to teach science, teach constructively…(from others)yeah, yeah (G2-S5)

Some of the reflections from preservice teachers indicate that they themselves were realizing the benefits of using inquiry-based instruction for teaching science as stated below:

“It has taught me that independent hands on activities keep the interest of students alive.” (G1-S2)

“Science is very boring, however the methods course taught me how I can make it fun.” (G1-S4)

This comment is significant in that through comments such as these preservice teachers were acknowledging that science as a subject is boring, but articulating their understanding that inquiry-based pedagogy or method of teaching it can make an otherwise boring subject fun to learn. Comments such as these indicated that preservice teachers were beginning to understand the benefits of using inquiry-based pedagogy to teach science. Accordingly, in the following comments preservice teachers’ articulated this understanding that learning should be student centered and not involve teaching to the text:

> Everyone should be responsible for their own learning. The teacher should only guide and help and not give the answers (G1-S1)
> Students want answers, however if they are left to explore they will learn better (G1-S6)

Preservice teachers also drew connections to how inquiry-based pedagogy can be used to teach other subjects such as math and literacy as indicated by the responses below:

> ---Well and I don’t think its just for teaching science like I think it’s a good method for teaching that you can apply to other subject areas you know like having students questions things and them wanting to know that I mean that really helps not just with science but with other subjects too because there’s no reason why students can’t construct knowledge when it comes to social studies, or reading, or English I mean they can do the same thing so….. (G2-S3)

The above response indicates that preservice teachers were becoming scientifically literate as they were beginning to understand that inquiry is not just for teaching and learning science but can also be applied to other areas. This finding is consistent with the vision of NSES to make scientific literacy for all a reality in the 21st century (NRC, 1996). Thus the above findings indicate that the science methods course was very successful in teaching preservice teachers inquiry and inquiry-based science instruction.

Contribution of the Science Field Experience to Learning Inquiry-Based Pedagogy

The majority of the preservice teachers who participated in the focus group discussions indicated observing science and specifically observing inquiry-based pedagogies to teach science in the field. Additionally, the preservice teachers reported that some of the inquiry-based science activities they observed in the field were similar to the ones they had been involved in the science methods course, indicating synergies in inquiry-based activities and pedagogy used in the field and those modeled in the science methods course as indicated by the following responses:

> I got to see the pendulum activity that we actually did in this class. (G4-S5)

> The notebooks of students in the field experience classrooms were organized with observations, data, asking questions, trying to answer questions, support with evidence and predictions. Exactly like our notebooks (G1-S4)

> In our first grade class (participant mentions another participant) we were actually together…we did not see science until the last couple of weeks and they actually then started doing a seed journal like we did in here…it was exactly the same thing we did….and then from there got eggs--chicken duck and turkey eggs--- and as first graders they explored like how the types of things the egg needs to survive and to hatch and now in the classroom they actually have live animals (G3-S6)

Thus, the majority of the preservice teachers reported observing inquiry-based instruction both in the field and the science methods course and reported noticing similarities between science teaching strategies used in the science methods course and those observed in the field. This was verified from the quantitative data collected through the Study Specific Questionnaire (SSQ).

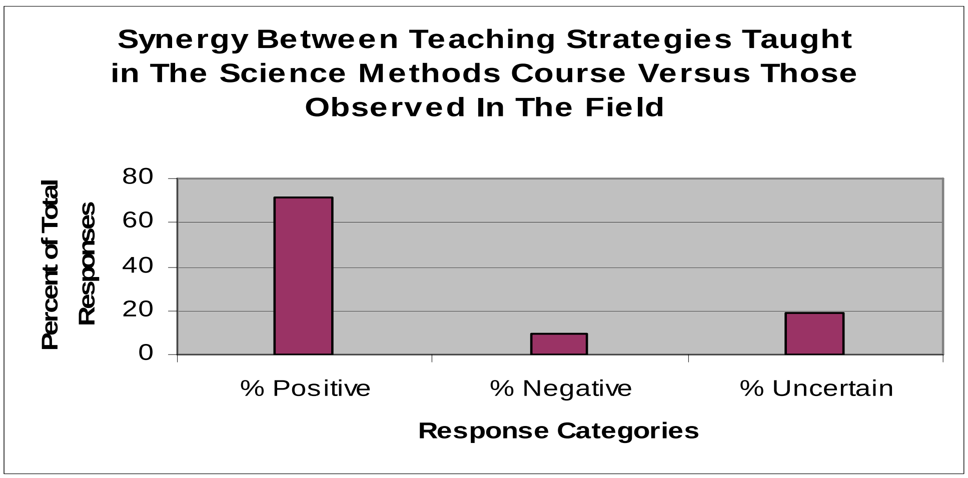
Data from the Study Specific Questionnaire on the dimension measuring similarities between instructional strategies demonstrated or learned in the science methods course with those observed by preservice teachers in the field, supports and confirms this finding. Specifically majority of the preservice teachers' responses on this dimension indicated similarities between the instructional strategies taught in the science methods course and those observed in the field.

Table 9 and Figure1 list the results on the dimension capturing preservice teachers perceptions regarding synergies they observed between instructional strategies modeled in the science methods course and those observed by them in the field experience. The data shows that majority (71.7%) agreed that there were similarities between the science pedagogies modeled in the science methods course and those they observed in the field. However there were at least 19.1% of the respondents who were not certain and another 9.2% who were negative. The latter category might constitute responses of participants who in the focus group sessions indicated that they did not observe much science teaching in the field due to scheduling conflicts.

Table 8:SSQ: Similarities Between Instructional Strategies Modeled and Observed

Response Category	Percent Score
Positive	71.7%
Negative	9.2%
uncertain	19.1%

Figure 1:SSQ: Similarities Between Instructional Strategies Modeled and Observed



Thus, the preservice teachers' reflections from the focus groups and their responses on the SSQ indicate that both science methods course and the science field experience provided good exposure to preservice teachers to inquiry and inquiry-based pedagogy in science.

Even though the majority of preservice teachers reported observing inquiry-based teaching in the field and reported similarities between instructional strategies modeled in the science methods course and those observed in the field, some preservice teachers reported having no exposure to science and hence to inquiry-based pedagogy through their field experience as articulated in the response below:

> Like my science observations in my classroom was non existent. We didn't see science at all ever. Yeah, uh huh (agreement from a few others).Yeah there was no science at all. Like they tried really hard, we had two people in our classroom plus a student teacher plus the regular teacher and the science specialist came like once a week, and we didn't even get to see math, we were there for reading and some of their specials and geography and that was it (G2-S1)

A few reported limited exposure to science and inquiry-based science instruction in their field experience as indicated below:

> Well we didn't really see much in field because we actually only saw science three hours like three one hour visits. The rest of our time was like in a regular classroom (G4-S4)
> I just really saw science like once or twice at the very beginning and then we went to MAP testing and then now we're back since MAP testing is done and now we're back in the normal swing of things and so she's getting back into science. (G2-S6)

Some preservice teachers indicated that even though they were placed in a science classroom for observations, their mentor teacher either did not teach science through inquiry or did not use inquiry properly as indicated by their responses below:

> And really the science I observed was like the teacher talking and the kids were writing stuff down. It wasn't any investigations (G4-S3)
> --Well I only observed three times and one of the three times all they did was read a magazine and then the other two times they kind of they did things but I observed her like using the science notebooks, but then like before she tried out the procedure but then she didn't follow through with it after. They did the experiment like she didn't come back and like have them write their conclusions or anything like that which is why I was like well I mean she could have just forgot (G5-S5).

Thus, some preservice teachers reported that inquiry in the science field was either not being implemented or was implemented inadequately. Others reported that perhaps they did not observe science because they were placed in the lower grades where science was not taught regularly as indicated by the response below:

> I mean I think for my observations there wasn't much experimenting, but maybe it is because I was observing younger grades, but like they haven't done experiments yeah they haven't done anything engaging or hands on but like our class went outside and watched the flagpole and were like oh if its moving a lot its really windy but nothing too extensive really (G2-S5).

Others explained that they did not see much science or inquiry-based pedagogy in science because their mentor teachers placed low priority on teaching of science. Hence their mentor teacher did not spend much time teaching science as indicated by the responses below:

> I saw science one day and she only teaches it if she has time during the week in my first grade class. They kind of like prioritize it… (G2-S4)
> --- Yeah it's low on the list. Their main focus is reading and writing which is kind of understandable but I mean you can apply it though yeah and you can have them write a story about science stuff, I don't know. (G2-S1)

One preservice teacher pointed out that they were placed in the science field experience in the winter 2006 semester, during which time the upper elementary grades in Missouri are preparing for the MAP (Missouri Assessment Program) testing. Therefore, they felt that the competing priority of preparing students for MAP testing made it difficult for their mentor teacher to teach science or science through inquiry as indicated in the response below:

> Like my class we've been preparing for the MAP test so that has like impacted like what we have been doing with our students but like we saw science at the beginning and they were doing a plant exploration that was really similar to our um what we had done like growing plants and then recording it in a science journal and then talking about like the parts of a plant and so that was really good but we just haven't seen since they've like been reviewing for the MAP Test. I haven't been there when she's

> done other science stuff and now their on social studies because they alternate social studies (G2-S3)

There were also instances where preservice teachers confessed that science and inquiry might have been taught by their mentor teacher, however they did not get to see it due to limited time allocated to field observations within the classroom or due to the coincidence that their observation times did not coincide with the science period:

> We didn't see whole units. Maybe we saw them go outside and like the next time they filled out a worksheet or maybe made a poster as an assessment like these kids made a winter poster, or a fall poster and children are playing in leaves so it is fall…stuff like that. We just got an incubator with eggs and stuff but I haven't been there to see what she's done with it but I think that she's probably going to do some really cool stuff with it hopefully, like there's a lot of cool stuff she could do with it……...(G2-S6)
> ---No we really didn't get to see….I mean I think a lot of the kids did the plant cause like I looked through one of the kids science notebooks and I noticed that they did something with seeds, they like looked at different kinds of seeds maybe so I guess that kind of correlated but besides that we didn't see electricity, (agreement-yeah, uh huh) we didn't see magnets, we didn't see any experiments… (G2-S4)

Thus, a few preservice teachers reported that their field experience did not reinforce the inquiry form of instruction they had learned and practiced in the science methods course as summarized by the response below:

> "--What we learned in here we didn't really get to see much in field" (G2-S1)

The above responses indicate that there were multiple reasons why some of the preservice teachers either did not observe or observed limited science teaching in the field. Some indicated that they did not observe science or inquiry in the field because they were placed in classrooms where science was not always being taught either because the grade levels did not require much science or because the time frame for their classroom observation did not coincide with the science period. Others indicated that their mentor teacher was busy teaching other subjects because either science was not a priority with their mentor teacher or because their mentor teacher sacrificed science to the multiple competing priorities posed by other subjects and standardized test preparation e.g. MAP testing.

The finding that some of the preservice teachers report either not seeing or having limited exposure to science and hence inquiry-based pedagogy in the field, might explain why some of preservice teachers responded on the SSQ either negatively or indicated being uncertain on the response category evaluating synergies between inquiry-based instruction modeled in the science methods course and observed in the field. However, a clear cut quantitative relationship cannot be made because all forty participants filled out the SSQ, while not all of them participated in the focus groups.

Understanding of Scientific Inquiry and Inquiry-Based Pedagogy

In order to capture preservice teachers' perceptions regarding their understanding of inquiry-based pedagogies to teach science, the following question was posed:

Q3: What do preservice teachers report regarding their understanding of scientific inquiry and inquiry-based pedagogy?

Preservice teachers' understanding of scientific inquiry was examined through the following two dimensions outlined in the NSES for learning science through for grades K-4: (1) fundamental abilities necessary to conduct a scientific inquiry, and (2) fundamental understanding about scientific inquiry. Preservice teachers' perceptions regarding their understanding of inquiry-based pedagogy for teaching science to grades K-4 was evaluated using the following two dimensions: (1) understanding the value of inquiry-based instruction in teaching and learning science, and (2) understanding of the recommendations of NSES for teaching science through inquiry.

Fundamental abilities necessary to conduct inquiry. Preservice teachers' responses indicate that their vocabulary is consistent with the understanding of abilities required to conduct an inquiry-based investigation, and is consistent with the criteria for fundamental abilities for science as inquiry outlined in the NSES content standard for K-4 (NRC, 2000) as illustrated by their responses below:

"Observing something ---then designing experiments --to see what that observation means" (G3-S1).

> Asking questions to understand why or how something happens.G3-S5)
> Trying to find the cause of a phenomenon or the reason why something happens…. why does it rain or why a magnet attracts or how do the plants grow. (G1-S1)

"I think it represents exploring something that does not fit with what we already know." (G1-S3)

"---You have to record….you have to have some sort of procedure you are going to go through I guess like a plan of what to do" (G4-S5)

"--Have some sort of conclusion and sharing of data like report your data." (G4- S6)

Thus, preservice teachers understood that inquiry involves observing a phenomenon, asking and answering a question, conducting an investigation to find the cause of discrepant event or phenomenon, keeping records of observations, using data to construct an explanation and sharing their findings with their peers.

Fundamental understanding about inquiry. Preservice teachers' responses also indicate their understanding of the fundamental concepts of inquiry. For example preservice teachers reported that they understood that inquiry investigations start with probing questions that spark curiosity, require tools to find information, can raise more questions that could lead to further investigations, that there is not one specific answer for each phenomenon, involve reflecting back on what the data is indicating in light of what is already known, doing more investigations to develop complete understanding, and could lead to development of new knowledge or discovery as articulated in the responses below:

"First one has to be curious and then we find out why it happens" (G4-S2)

"Okay it starts with a prompting question or just something you want to know about, and then the facilitator provided tools and ideas and resources that you might need. I just wrote my reflection on this" (G5-S1)

"I think about open ended questions there is not just one specific answer you're looking for. And as you're looking for information or investigating something more questions may come up" (G3-S2)

"Documenting all the data that you found throughout and put it probably like in science journals…..collaborating with peers also" (G3-S4)

"--You have to have variables, you have to have a question, you have to have tools so you can investigate a variety…" (G4-S3)

"--Then after you um go through your investigation you have to like look back and see if your hypothesis is correct" (G4-S2)

“Finding the results of the investigations--- so you can do more investigations” (G3-S3)

“--sometimes data can lead to further investigation—I mean it raises more questions which too have to be answered” (G4-S3)

“It could ultimately lead to a discovery!” (G4-S1)

The above responses indicate that preservice teachers’ understanding of concepts associated with inquiry is consistent with the NSES (NRC, 2000) recommendations for fundamental understanding about classroom inquiry articulated in the Standards for grades K-4 (Chapter One). Preservice teachers’ analogy to discovery through inquiry is an indication of their understanding of how scientific knowledge is generated.

Thus the preservice teachers’ responses show that they understand that learning science is an active process, that learners must be exposed to activities that engage them to answer scientifically oriented questions, that learning is something students do, not something that is done to them, that learners answer scientifically oriented questions by making observations, gathering data, developing explanations, evaluating finding, communicating results and justifying their explanations to their peers. This indicates their understanding of abilities and concepts of scientific inquiry.

An interesting finding was that not only did the preservice teachers understand the fundamental concepts of what constitutes inquiry, they also drew connections to the use of inquiry in other fields. Most notable was their analogy to the ‘Show Me’ motto for the state of Missouri which in a way exemplifies what inquiry investigations are about. This application of inquiry principles indicates their cognitive development or their depth of understanding of inquiry as illustrated in the response examples below:

“Not accepting what we see but questioning everything, just like the motto of Missouri, the ‘show me’ State, we must back up an explanation with information or data” (G1-S5)

“Yes, what I mean is that it is an approach; that is how we should go about investigating things just like on a crime scene” (G1-S1)

“It is no different than us exploring the cause of a behavior issue in class” (G1-S2)

“Well, in a way we use inquiry principles to investigate conflicts**.** We ask when, how, who and why of what happened” (G1-S2)

Preservice teachers responses also show that not only did they develop an understanding of the use of inquiry to answer scientifically oriented questions, or how to analyze root causes of life events such as crime scenes and conflicts, they also applied their learning about science concepts to explain the workings of household appliances and gadgets as indicated by their response below:

“--The little deals in the cabinets that keep them closed, Yeah we really applied a lot of the stuff to our homes and how our everyday life like how we applied science to our everyday life” (G2-S4)

This drawing of connection of inquiry to day-to-day living is further proof of their understanding of inquiry and science concepts. This understanding is consistent with the vision of the NSES regarding development of scientific literacy articulated for all students by the 21st century (NRC, 1996).

Another interesting finding was that preservice teachers understood the connections between constructivist approach to learning and inquiry-based pedagogy indicating cognitive development in the area of science pedagogy:

> I think a lot of the inquiry and constructivism issues overlap and so most of what I knew about it came from constructivism because that was heavily taught in our other our previous classes. What I know of inquiry came from this class because we have like focused on it this whole semester. (G3-S6)

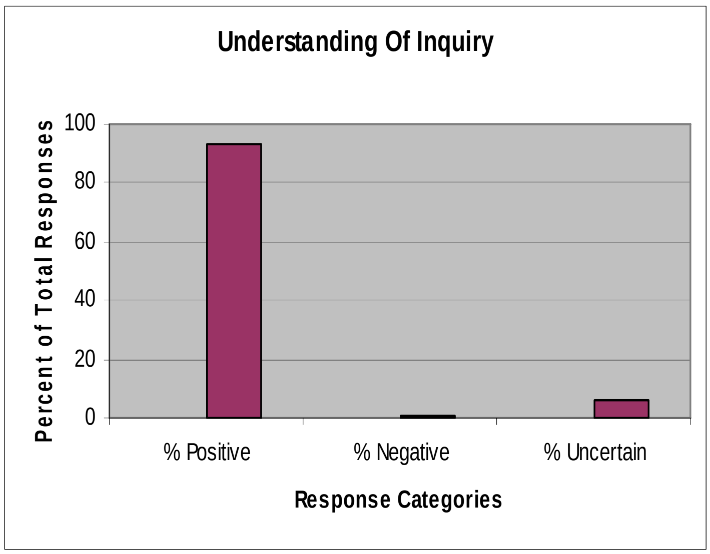
Thus, the preservice teachers' responses indicate their understanding about the process of inquiry, the abilities necessary to do inquiry, the fundamental concepts about scientific inquiry and the how inquiry-based teaching is related to the constructivist approach to learning.

Cumulatively, the above responses indicate that Preservice teachers' understand the fundamental concepts about scientific inquiry as articulated in the Standards. This was supported by the preservice teachers' responses on the SSQ. Table 10 and Figure 2 show the results on the dimension capturing preservice teachers' understanding of classroom inquiry. The data show that majority, 93.3%, of the preservice teachers responded positively on this questionnaire indicating their understanding of inquiry, while 1% responded negatively indicating a lack of understanding about inquiry and about 5.7% were uncertain about what they learned about inquiry.

Table 9: SSQ-Preservice Teachers' Understanding of Inquiry

Response Category	**Percent Scores**
Positive	93.3%
Negative	1.0%
uncertain	5.7%

Figure 2 : SSQ- Preservice Teachers' Understanding of Inquiry



The data presented above indicates that the science methods course at the UMC was successful in teaching preservice teachers understanding of abilities necessary to do inquiry, and concepts related to scientific inquiry. The application of science concepts by preservice teachers' to the workings of household appliances, and of inquiry principles for crime scene investigation and conflict resolution are further indication of their understanding of inquiry and science. Making connections to explain day-to-day phenomena is consistent with the vision of the NSES for scientific literacy for all citizens. Scientific literacy according to the Standards means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences" (NRC, 1996, p. 22):

Understanding the value of inquiry-based pedagogy in science. Preservice teachers' perceptions regarding their understanding of the value of inquiry-based pedagogies for teaching science were examined to see if they understood the benefits teaching and learning science through inquiry. Preservice teachers' reflections on the focus groups indicate that they understood how inquiry-based instruction can facilitate student learning i.e. the preservice teachers understood the value of inquiry for bringing about lasting/sustained student learning in science, for keeping students interested in science and for making science fun as indicated by some of the responses below:

> It allows the students to construct their own knowledge (G5-S1)
>
> If children are allowed to learn by doing then they will remember what they learned (G3-S1)
>
> Students become self reliant (G1-S2)
>
> Children are naturally curious, if we let them explore then they will like science and hopefully go into sciences when they grow up (G3-S1)
>
> It teaches students how to overcome initial frustration and keep trying (G1-S5)
>
> It allows the students to like discover on their own like ask themselves questions and kind of more learning on their own (G3-S2)

Preservice teachers' responses indicate that they realized that learning and teaching science through inquiry can help children like science, become independent thinkers, and become interested in science. One notable point made by the preservice teachers was that inquiry-based pedagogy can get students interested in science which could ultimately lead students to pursue science in higher education which would fill the shortage of scientists in the United States as indicated in the responses below:

"It makes students independent thinkers, more like how scientists are" (G1-S4)

"If students grow up learning how to do inquiry maybe they will become scientists some day" (G3-S5)

"--Ya there is such a shortage of scientists, we have to develop students to like sciences" (G3-S1)

The above responses indicate preservice teachers' understanding of the importance of getting students interested in science through inquiry.

An interesting observation from the preservice teachers' reflections about the value of the learning science through inquiry was their understanding of the value of taking students into a natural environment where their minds can freely observe, explore and develop explanations for natural phenomena (e.g. the woods) as articulated below:

"We took a field trip to The Devil's Icebox" (G3-S6).

> We basically just got to look at the ecosystems around us and ask questions. He collected some organisms in containers and we were going to watch them. It kind of gave us ideas as to what we could do with our plants (G3-S6)

> --It was kind of nice because we didn't like bring like paper or pencil, (agreement-yeah, yes) we got to explore it without having an assignment with it (participants start talking over one another). And we came back and we asked questions like about what our exploration and we took pictures and kind of bonded over it (G3-S2)

> Yeah that was cool, that was the best one! (Laughing) Yeah we went through like the woods and checked out all the moss and like lizards and like the environment and the caves, but it triggered a lot of questions (G2-S5)

> It showed us that sometimes it's good to take kids out of the classroom and to put them into a different place because that can make them think

> about things differently. It can trigger questions and think about things that they might want to explore or experiment with (G2-S6)

The above responses indicate preservice teachers' understanding that inquiry in science is not only restricted to experimentation in the class but can also be done out in the field.

It was very interesting to note that during their reflections in the focus groups most of the preservice teachers felt using inquiry-based pedagogies to teach science would make learning science more meaningful for children and help them develop confidence to do science as illustrated by their responses below:

"Be more of a positive experience rather than an experience that they have to do" (G3-S2)

"As students succeed in their tasks, they develop confidence in science" (G1-S1)

"Also it gives them confidence in themselves" (G5-S1)

"Students develop confidence when they are allowed to explore on their own. However there have to be strict rules enforced" (G3-S3)

"After independently exploring experiments assigned in class, I feel more confident to teach science" (G1-S4)

The finding that the preservice teachers understood that inquiry-based science instruction can give students confidence in science is especially interesting since a recurring theme in science education research has been that elementary preservice teachers do not themselves feel confident to teach science.

Another important observation noted during the focus group discussions was that preservice teachers realized that making science fun and interesting through the use of inquiry-based science instruction can also help with classroom behavior management as illustrated in the responses below:

“Because the students are conducting it they tend to be more interested and therefore put out a better effort than if somebody is just telling them” (G4-S5)

“The time passes faster when children are involved in activities than when say the teacher teaches to them” (G5-S5)

The above responses indicate that preservice teachers understood how the use of inquiry-based pedagogy for teaching science can help them make science more interesting, and help them manage the classroom better. Preservice teachers’ view about classroom management is contrary to the finding from the delivered curriculum (Section I) in that the graduate student instructor of the science methods course had indicated alerting preservice teachers about possible classroom management problems and frustrations faced by new teachers when trying to implement inquiry-based pedagogy which is supported by reports in literature that elementary preservice teachers indicate concern about classroom management when implementing inquiry-based science lessons (Hayes, 2002).

Another benefit cited by the preservice teachers of the use of inquiry-based science instruction and learning was the social interaction promoted through this form of learning as illustrated by the responses below:

“It promotes social interaction and learning from each other” (G1-S2)

:It shows how observations made by one group can be used by another group to answer their questions” (G1-S5)

“We were helped by the groups around us. I think discussing with other groups in the class and our peers we were able to do the experiments” (G1-S3)

The responses indicating social interaction are consistent with the instructors' responses in Section I stating that they facilitated learning of inquiry through inquiry-based activities by having preservice teachers work in groups and learn from each other. The understanding of the value of social interaction for learning is a hallmark of constructivist approach for learning science and is consistent with the Bandura's (1977) contention that vicarious experiences where one learns through peer interaction promotes self-efficacy.

An interesting reality that emerged from the preservice teachers' reflection was that even preservice teachers who considered themselves structured, appreciated the value of the unstructured constructivist approach to learning science. These preservice teachers indicated that being pushed out of their comfort zone of working in a structured environment gave them confidence to teach science. This again shows cognitive development of preservice teachers in the area of instruction as illustrated by the response below:

> We really didn't know that much about it so it's just been good to kind of put a name to what I experienced in school and kind of put a purpose to that so it wasn't like one teacher choosing to do inquiry method and another choosing inquiry there was like a reason behind it. And I enjoy inquiry better like when there's open ended questions and stuff like that versus the strict concepts of the inquiry method. And that was like big for me because I am a very structured person like very concrete and so like but experiencing inquiry I do enjoy that and I think its good also for students where there's not a right and wrong. And like kind of being pushed outside of my comfort zone has been good and like kind of finding confidence in that like all 5 of us might have different answers but they all might be correct. (G3-S5)

Understanding the NSES recommendations for inquiry. Another dimension used to access preservice teachers' understanding of inquiry and inquiry-based pedagogy was to capture their perceptions regarding their understanding of the NSES recommendations for science as inquiry for grades K-4. This assessment also helped capture preservice teachers understanding of how the NSES recommendations for inquiry-based science are integrated into the science methods course. Results of this evaluation indicate that preservice teachers' were familiar with the recommendations of the NSES for teaching and learning science through inquiry. Specifically the preservice teachers indicated being involved in class discussions on the NSES, observing teaching strategies that used NSES recommendations for science as inquiry, preparing science lesson plans incorporating the recommendations of NSES for inquiry and presenting science lessons incorporating inquiry-based teaching. The responses below indicate the preservice teachers' understanding of how the teaching strategies they learned in the science methods course and observed during the science field experience are consistent with the recommendations listed in the NSES for abilities necessary to learn science as inquiry:

"---Oh they are perfectly consistent, I mean because everything is so accurately correlated with the standards" (G5-S3)

"Ya, all the skills we used for inquiry are right out of the standards. For example we made observations, generated and recorded our data, kept lab notebooks and then drew conclusions" (G5-S4)

"We also shared our findings and reported them to the class. This too is in the standards" (G5-S5)

“And we had to talk about the standards a lot and that really helped because the standards really do outline everything we need” (G5-S4)

“We saw how the National Science Education Standards are integrated into teaching of science” (G5-S6)

“I liked the way we tied everything to the standards” (G5-S2)

“Ya, that was another thing, we were very aware of how the National Science Education Standards were being satisfied through these inquiry-based activities” (G5-S3)

Thus, preservice teachers’ responses on the focus groups indicate their knowledge of how the NSES recommendations for science as inquiry are integrated into the science methods course. This finding is supported and confirmed by the data from the interview transcripts (delivered curriculum) with the instructors and from the evaluation of the course syllabus (intended curriculum) indicating that the NSES recommendations for inquiry are in the science methods course through the use of multiple teaching strategies. Thus, the intended, the delivered and the received curriculum are aligned with respect to integration of NSES recommendations in the science methods course for doing science as inquiry. Specifically, the findings indicate that preservice teachers were taught and understand the abilities necessary to do inquiry, understand the concepts about scientific inquiry and understand the value of inquiry based pedagogies for teaching science outlined in the NSES for grades K-4. The findings also indicate preservice teachers’ understanding of inquiry and science concepts extends beyond the classroom as they made connections to use of inquiry principles and science concepts to solve day-to-day events. This latter understanding is an indication of their development of scientific literacy consistent with the vision of the NSES.

Reflections on Learning Science through Inquiry

Preservice teachers' responses on the focus groups were examined for their reflections on learning science through inquiry. The preservice teachers reported that they were initially frustrated with the lack of structure to the inquiry-based experiments as indicated by their responses below:

"---Sometimes it was very frustrating trying to figure out on our own what was going on" (G1-S6)

"---It was a little frustrating at first since we did not know how to go about it, but once we got going we enjoyed the experiment" (G4-S6)

Both the instructors teaching the science methods course indicated using the constructivists approach to teach and model pedagogy for science as discussed in Section I. Specifically, they both used the 5E Instructional Model. They actively involved preservice teachers in partial and full inquiries. The latter required preservice teachers to design their own experiments to either explain a discrepant event presented to them or to answer an operational, scientifically oriented question posed by the instructors. This inquiry-based learning was especially hard for some preservice teachers who admitted not being strong in science content which increased their anxiety of exploring/working on their own and finding a solution to the question asked. They indicated that they would have preferred to have their instructors provide some initial guidance or direction as illustrated by the following response:

"Some assignments, like the seeds experiment, were easy others were frustrating at the beginning because I am not very strong in science content and therefore had a hard time getting started" (G1-S2)

Preservice teachers' responses indicate that they understood that inquiry-based learning or constructivist approach to learning science requires students to explore on their own and learn from their experiences, but voiced frustration with the lack of guidance or structure provided by the instructors as indicated by the responses below:

> ---I think the frustration for me has been that he doesn't really give us a whole lot of structure for assignments and guidelines or anything yet when he assesses us or evaluates the assignment he grades it according to a certain set of guidelines and I don't know about you guys but that has been very frustrating to me (Laughing) (G3-S3)

"Because I don't know what his expectations are. I understand constructivism but I understand that there are certain amounts of guidelines that you should provide" (G3-S1)

The inquiry-based teaching approach was especially frustrating to those preservice teachers who were more used to structure in their work as articulated in the responses below:

> It has been bittersweet. There is always good in a bad situation. We have taken away things and we are more structured people and whenever you come into a situation where it's not structured it makes it more difficult. We know that we want to have structure and we know the feeling of being frustrated (G3-S2)

It appears from the preservice teachers' responses that some of their inquiries were more open than guided resulting in frustration for preservice teachers as indicated by the response below:

> It was all inquiry. He was really open ended which is kind of how we should be….it was frustrating at times (G4-S1)
> He was always challenging us with questions (G4-S6)

The frustration voiced by preservice teachers about learning in a constructivist environment was picked up by the instructors who reported in their interview transcripts that most preservice teachers were frustrated and struggled with open inquiries.

This frustration with open inquiry or learning in a constructivist environment where students are responsible for constructing their own knowledge is consistent with Piaget's (1975) expectation of how human learning occurs. According to Piaget's theory of human development, "learning begins when individuals experience disequilibrium" and "to bring their understanding back into equilibrium, they must adapt or change their cognitive structure through interaction with the environment" (as cited in NRC, 2000, p. 34). Piaget's work was the basis for the learning cycle instructional model used by the instructors in this course (Bybee, 1997). Therefore it is not surprising to find preservice teachers reporting that they experienced frustration with inquiry form of learning.

An interesting finding was that even though initially the preservice teachers were lost or confused, towards the end of an inquiry-based assignment they came through constructing their own knowledge. Specifically, on reflecting back on the instructional strategies used by the instructors to teach science, preservice teachers confessed that the successful completion of inquiry-based experiments, in a constructivist environment gave them a sense of pride and confidence in their own abilities to do science and helped them realize the value of the use of the constructivist approach to teaching and learning science as indicated by the responses below:

"It was very frustrating to not be guided, but in the end we realized how it helped us learn by doing" (G1-S5)

"Sometimes I felt that we could have been more efficient if he had given us some direction. However now as I look back, I realize that he was trying to get us to construct our own learning" (G1-S1)

“Yes, I for one was always lagging behind as I am not so strong in science. I was frustrated because I did not know where to begin. But once I got going I enjoyed the independent exploration” (G1-S5)

“Wow! I did not realize how much we learned in this class. Sitting down and talking about it really made me see how far I have come this semester!” (G1-S4)

“We have learned a lot. I guess the frustration was worth it” (G1-S1)

Thus, after an initial phase of frustration preservice teachers were able to develop an appreciation of inquiry-based learning. This finding is supported by the interview transcripts from the instructors presented in section I of this chapter.

Preservice teachers’ responses also indicate that even though they experienced frustration with the constructivists approach to learning science, they started to embrace this form of pedagogy for teaching science in their own classroom as indicated by the response below:

> I hated them, but the way that he let us do it on our own and made us answer questions and like had the questions for us and the things to think about and we had to discover things on our own, you know pretty much a direct model of how we should be teaching our students letting them (G5-S1)

In summary, though the preservice teachers were initially frustrated with learning science through inquiry, and did not feel prepared to independently handle science projects assigned to them, they were able to traverse their way through the challenge and on reflecting about their experience realized the value of inquiry-based pedagogy for learning and teaching science. Preservice teachers’ reflections from the focus groups indicate that this transition in thought was facilitated through the positive outcome in their multiple inquiry-based activities, from peer discussions necessitated through lack of instructor interaction and through their reflection on the benefits of inquiry-based learning.

To evaluate the data for preservice teachers' perception regarding the development of their own pedagogy for science, the following sub question was posed:

Q4: What do preservice teachers report regarding the influence of inquiry-based pedagogies demonstrated in the science methods course or observed in the field on their personal pedagogy concept development or their intention to use inquiry based pedagogy for teaching science?

Intent to teach science through inquiry. When asked by the researcher to reflect back on the science teaching strategies they had been exposed to in the science methods course and science field experience, and indicate if they would use inquiry-based teaching strategies in their own practice, most preservice teachers indicated that they were positively disposed to the idea of using inquiry-based instructional strategies for teaching science as indicated by the responses below:

"I will use it. This class has rubbed off on me. I like the constructivist view of teaching. It allows students to build on what they already know" (G1-S3)

> Yes, most definitely I will plan to use inquiry to teach science. I love the way my field science was done. And since that was like perfectly inquiry I would definitely want that. I want, I want I mean I want inquiry in my also we like talked about that inquiry-based things in math also and so you know like I really want that to be an element in my classroom, open questions, open conversation and correlation. I mean all of the aspects I really want my students to be comfortable with in the environment (G5-S1)

Some of the reasons given by preservice teachers for their intent to use inquiry-based pedagogy were to develop student interest and sustain student knowledge in science as articulated in the responses below:

> Definitely, yeah, yeah, for sure. Um well I will obviously because it's a good way for the kids to be interested you know to start their interest in the topic like we had a lesson where they brought in animals and then they all just came up with all these great questions and we were the ones that were coming up with the questions like what does it do, and stuff like that and it is just a great way to get them interested because a lot of kids might be scared of science in a way. Their not I mean I know I was, I was like oh my gosh science its gonna be so hard and so just introducing something and coming up with questions I don't know…good strategy. (Laughs)(G2-S5)

> --Um yeah I plan on using inquiry because I think it is just a good way for students to construct knowledge and like I remember that like in my science classes the ones where I remembered the most stuff was in like the hands-on ones where I really got to explore and use the materials and stuff and um not like the ones where I was sitting in like a lecture hall and having my teachers put notes up on the board and copying them down.(G2-S6)

Another reason given by the preservice teachers to use inquiry-based pedagogy was that they understood that inquiry-based learning was one of the better ways for their students to learn science therefore they were inclined to using this form of instruction in their own teaching of science as indicated by the responses below:

> I didn't really know what it was but I now definitely think its definitely one of the best ways for students to learn about science or about anything is just to discover it themselves and to just guide them through that process. (G2-S3)

They were also motivated to inculcate interest of science in their students by using a method to teach that would make learning science more fun for their students as articulated below:

> --Um I would use inquiry because I think it is really great and its something that you can use before a lesson you know to start a unit or during a lesson and when I think of science I think of like experiments and of making it fun and like that's what I want my students to think about because like some students think its boring if you just have to sit there and you know write down notes and I think that you know the more that students are interested in it the better off they'll be so I would definitely use it (G2-S4)

The intent of the preservice teachers to use inquiry-based pedagogy was also coming from their desire to have their students develop greater confidence in science than they had and indicated the use of inquiry-based instruction was the way to accomplish it as articulated by the response below:

> -- I want my students to have a greater confidence in science than I did because I think it's definitely an area where I just I was just really, really unsure of myself and that has really affected my now because I didn't even like really care about science until like this class and I think it does have its place and you do have to learn about it and know about it and I think inquiry is the best way to do that (G2-S1)

Another reason for using inquiry-based instructional strategies provided by the preservice teachers was that working in a constructivist environment with inquiry-based activities where students are responsible for their own learning, keeps students involved and interested in the subject, and inculcates a positive attitude in students for school work as indicated in the response below:

> I think it really helps students become really engaged in what you're doing in science and its fun and its interesting and they have more of a positive attitude about doing schoolwork and stuff like that because you know they're not being pushed, you know its not like teachers saying you have to do this, its more like students being like oh well developing questions in their head and being curious abut what their experimenting with (G3-S5)

Preservice teachers' reflections on the focus groups also indicate their understanding that though inquiry-based instruction is a good way to teach science and keep students interested in the subject, there might be occasions when they would have to bring more structure into learning and divulge from inquiry such as for MAP testing as articulated by the response below:

> I think that in like the grand scheme of things I think that students would probably rather do an inquiry lesson, find out about a new subject and then journal in a science journal where they're still writing they're still having

> that integration or whatever but its close to something fun, because I think a lot of times whether no matter how good a teacher you are there are going to be times that you're going to have to have structure and do those certain quote MAP testing things and so I think this is a great way to keep fun in the classroom because that's really what its all about (G3-S6)

The response above indicates preservice teachers' understanding that inquiry-based teaching strategies are not the only instructional strategies that they will use to teach science. This understanding is consistent with the NSES recommendation that teachers of science must use a mixture of teaching strategies to teach science or that "teachers should use different strategies to develop the knowledge, understandings, and abilities described in the science content standards. Conducting hands-on science activities does not guarantee inquiry, nor is reading about science incompatible with inquiry" (NRC, 1996, p. 23).

One of the main reasons cited by preservice teachers for their intent to use inquiry-based pedagogy to teach science was that they themselves had positive experiences learning science through inquiry and therefore felt committed to using inquiry-based instructional approach to give their students positives experiences with science. The following responses reflect preservice teachers' intent to use inquiry-based pedagogy to provide meaningful, personal experiences to students and to sustain and develop student interest and knowledge in science:

> I'll use inquiry in my classroom because I've seen it work and I'm one of the people that like have to see it for myself or actually do it for myself before I believe it and so since I've actually done it and seen that it actually works and I remember stuff I'll use it and I still think I know from my experience I remember the things that are the most meaningful to me or that were fun and so I want to make science meaningful and personal to my students so that they actually learn and get something out of it and its not just they learn it for those 8 weeks and then its gone. And it's like they've never even done it before. Retention is important (G2-S4)

> Okay I would also use inquiry and I think it engages students but also it develops long term memory. Fun is a term we use and not that a classroom has to be all about fun but it can be and so there's an opportunity to. But just like I think students are going to remember it and their maybe they'll remember when they get into high school and are doing things and even college, if they can just take little pieces from things that they learned at a young age and be like able to tie that in later on I think inquiry allows for that and like its not and I am excited because it does allow for structure but its not structure that's like answer these questions and I think whenever there's just a list of questions to answer then it just becomes routine and let's just get through these questions and be done. Inquiry allows for structure within open ended questions and allows for creativeness, interest and engaging and it also allows for like talking about the five E's also like extension and stuff like you can extend it which kind of goes along with long term and you can extend it to things as they get older or extend it to things later on in the school year. But yes I'll use it. (G3-S4)

Another important reason cited by the preservice teachers for their intent to use inquiry-based instruction for teaching science was that inquiry-based pedagogy can promote cognitive development of their students through inspiring 'higher order thinking' as indicated by the response below:

> Definitely I will use inquiry. Yes, I will use inquiry as well because I think that like from my teaching lessons I think it can be structured its not just this crazy idea where its like okay go experiment, I mean making the lesson plans we saw that you come up with certain questions that you want to ask and I think that its great for students to think of higher order thinking and um and so I think that they're just not going to forget what they learned tomorrow, its not just taking a test. I think that through inquiry you learn information for long term memory instead of just short term memorization. It's sort of like an experience (G3-S3)

Thus, preservice teachers' reflections indicate their intent to use inquiry-based pedagogy to teach science. It was interesting to note from preservice teachers' reflections that one of the reasons they gave for using inquiry-based instruction to teach science in their own classroom was that they had had a positive experience with inquiry-based instruction which made them realize its value for making science fun and enjoyable for their students.

Some other strategies for teaching science that preservice teachers indicated they would use dealt with facilitating student inquiries such as how to use inquiries and scientifically oriented questions to develop student interest. The following responses elaborate the teaching strategies they learned from the science methods instructors and their personal learning from it:

> Maybe even asking them like what they wonder about, what they want to know about like their interest, cause a third or fourth grader would think that was really cool if they got to learn about something that interested them and yeah. To an extent letting them pick the topic too, I mean you have to make sure it's something they need to learn and not something random. (Laughing) (G4-S5)

> It's also good because it helps us think about how to design an inquiry lesson kind of almost going from scratch and pulling together different resources, like I know I went online and I talked to other science teachers and things and just used a bunch of different resources to try and pull together an inquiry lesson. (G3-S2)

> I think because it starts with a question and you're asking your own questions but then students are even like us in our class we had to ask a lot of questions and I really got to figure out my own answers since it was my question it was more meaningful to me. Agreement from the group- Uh huh, yeah! (G2-S4)

The above response indicates that the intent of preservice teachers to use inquiry-based pedagogy was coming from their understanding of the value of inquiry-based instruction to inculcating student interest in science and to make the subject matter interesting to the students.

Inquiry-based pedagogy versus teaching from the text. One of the key reasons given by the preservice teachers for using inquiry-based pedagogy was that it would help them get away from dependency on the text. This finding is significant as it shows preservice teachers' appreciation of how inquiry-based pedagogy can make learning science more interesting for the students than learning from the text as articulated below:

> Because well like, before I took this class I thought we were going to be reading like science textbooks to explore like science concepts through elementary school, but we did everything without those textbooks and it made it a lot more interesting and I don't think I want to use just textbooks in my class to like I don't know teach. (G4-S5)
>
> I will because like she said it is a good strategy, but also because if you just base everything out of a textbook or just give them information it limits them on what they could possible know, because they might ask questions about things that aren't being taught and so they are questions that maybe you didn't think about but they really wanted to know. So if you allow them to ask those questions then they will probably learn a lot more than just the basic textbook stuff. (G2-S3)

Preservice teachers credited the preparation of inquiry-based lesson plans they were required to prepare for the science methods class with inculcating a comfort and desire in them to teach science through inquiry. Preservice teachers reported that the preparation of these inquiry-based lesson plans brought them the realization of how much more interesting science can be if inquiry-based instructional strategies are used rather than lecturing from the text as outlined below:

> Throughout the last couple weeks we've been teaching our lesson plans in this science methods course and basically the main purpose it so that we can show the different expectations for the different grade levels like how you can include inquiry into them and even as college students its definitely just more interesting and if its more interesting for us hearing it for like the gazillionth time it has to be very interesting for the kids hearing it for the first time or being able to do it for the first time. And one

> thing I'm thinking of is like um we did sound waves and I feel like in a normal class if you were just to lecture that, you that could definitely probably be a tedious thing to teach or as actually getting tuning forks and like putting them in water so you can see the vibration I just think that first of all it will be easier to learn and they will definitely have fun and want to continue. (G3-S6)

Thus, one of the key take away messages that the preservice teachers indicated was to rely less heavily on text but more heavily on student centered learning. This is consistent with the teaching strategy modeled by the science methods instructors. The preservice teachers articulated that inquiry-based pedagogy is much better in bringing about students' understanding of science concepts than having them memorize concepts as this form of instruction helps students build on what they already know and thus sustains their knowledge as indicated in the responses below:

> Yes, I will use it also um the great thing about inquiry aside from being engaging and motivating you know its so much away from just pouring information into a student from having them memorize things. They're not really learning their just you know retelling what you've already told them so um the great thing about inquiry is they can use their prior knowledge, build an understanding, and really hold onto that understanding and take that with them wherever they go so I don't know that's….Everybody else just kind of said all the good stuff. (G3-S2)

> I remember science like as a kid and it was the science book and you got it out and you read it and you got nothing out of it and you were like oomph! And so I guess knowing that and like what we did learn about inquiry makes me think that it would be so much more meaningful for them. (G4-S4)

> "I think you just learn a lot more and you remember it because I don't feel like I remembered much from elementary science but if I like did it myself I may. Because it was just some teacher telling me what I should know" (G4-S1)

Thus, preservice teachers' responses indicate that they understood that instructional strategies using inquiry would be more readily accepted by their students as these strategies would allow students to take ownership in their learning and develop interest in the subject. Therefore majority of the preservice teachers indicated their intent to use inquiry-based teaching strategies to teach science rather than teaching from the text as the latter strategy leads to students being bored and disinterested while the former strategy results in students who are involved, motivated and interested. In short, the preservice teachers' reflections indicate that they understood the value of inquiry-based instruction. Specifically, they understood that inquiry-based pedagogy helps develop student interest in science, gets students to construct their own learning, sustains student interest in science, improves student attitudes towards science and builds confidence in students to do science.

Apprehensions about using inquiry-based pedagogy to teach science.

Even though majority of the preservice teachers reported their intent to use inquiry, some of them also reported being apprehensive about using inquiry-based instruction. For these preservice teachers the anxiety was caused by the realization that teaching science through inquiry might raise questions from students which they might not be able to answer as articulated below:

> I kind of worry that they'll ask a question that I won't know. I taught a math lesson and they asked me how many ounces are in a pound and I was like good one I don't know. You know I should have I should have known that I had just forgotten and your kind of like you're on the spot, but if you're open with your students if you have open communication with your students then that is not even a problem. So I guess just being prepared about to have really good investigations is the only thing that I would worry about. Like knowing exactly they're , being able to predict exactly what their questions are going to be and being able to predict what they are going to wonder and think and learn (G2-S3)

Others worried about the increased time it would take to develop inquiry-based lessons as articulated below:

It takes a lot of effort to set up inquiry-based lessons (G1-S6)

I think it takes more preparation definitely. I think though like if you do have a school that supports it, it will fit in with so many other subjects because in literacy you take running records and your supposed to probe them there and in math its like you can just it makes your whole teaching like align with all the other subjects as well too and it gives you like tips for other subjects (G4-S4)

Realistically at first I don't think that as a first year teacher I will be able to use inquiry as much. There will be so much to do so I don't know if I will have the time to plan it all out and do it in the classroom (G1-S2)

Preservice teachers were also apprehensive about whether they would have enough teaching time to teach science through inquiry in the current set-up of elementary schools as articulated below:

"I would like to use it but I do not know whether I will have enough class time to work it in" (G1-S1)

Thus, the above responses indicate that even though majority of the preservice teachers had indicated their intent to use inquiry-based teaching strategies to teach science, some of them were apprehensive about whether they could implement inquiry in their classroom primarily because of their concerns of their inability to answer students' questions arising during inquiry-based activities, the increased time and effort it would take to design inquiry-based lesson plans or the inadequacy of time allocated to teaching science through inquiry.

Some preservice teachers expressed apprehension about the use of inquiry form of instructional strategies in their teaching practice because they feared lack of support from school administration to implement inquiry-based instruction as reflected by the response below:

> I think it depends on how much support you have in your school. Because like I may teach in a really rural school like a small town and if there's still like everyone else around you is teaching out of the textbook then its going to be really hard to implement that and do it because you won't have the materials (G4-S3)

However, most preservice teachers indicated that if they received the right support from their school administration, they could get around these challenges because of the good exposure they had to inquiry-based instruction through the science methods course which made them confident to not only teach science but to teach science as inquiry.

One encouraging finding was that some preservice teachers, though apprehensive, outlined solutions for dealing with lack of time for preparation and teaching of inquiry-based science. Specifically, they stated that with the multitude of resources for inquiry-based instruction available e.g. on the Internet, they felt comfortable to use inquiry to teach science as reflected by their responses below:

> I think the one thing like we learned about all the different curriculum and some of them have like kits and everything's ready to go, so I think like if you had like a guide and like a kit that was based on inquiry that would make it a lot easier. But I would definitely use it (G4-S5)

"The one we studied was science and technology for children. You can go online and its like backed by the Department of Education and the Smithsonian Institute" (G4-S1)

"--They have like a teacher's guide and a student's guide and like a big box of materials and tools that you need so that would help you and you'd feel more comfortable" (G4-S2)

"-Yeah because you'd have support. You wouldn't just behaving to come up with it completely on your own" (G4-S3)

These responses indicate that preservice teachers were overcoming their apprehension about teaching science through inquiry by taking comfort in the ready availability of instructional materials for teaching inquiry in science. This is contrary to the findings from the delivered curriculum as the instructors in the delivered curriculum (Section I) indicated that preservice teachers in his classes had difficulty evaluating instructional materials for suitability to teach science through inquiry, because of their limited knowledge of science content.

Observations of teaching strategies used by their mentor teachers in their science field also helped preservice reflect on what teaching strategies they liked and would use and which ones they did not like and therefore would not use. Thus, their personal concept of science pedagogy developed as they were exposed to the teaching strategies modeled in the science methods course and the science field experience as illustrated below:

> And I've learned like throughout observing teachers that like watching teachers like ooh I'm not going to do that, you know or like that's something that she probably needs to work on. (G3-S2)
> I loved the science specialist in my field she was awesome. Um, pretty much everything she did I want to be that in science. Like she always was so organized and so prepared but she came in with her little cart because she has to travel and our classroom is in a trailer so I mean she has to travel even farther for that and up the stairs and bring her stuff in, she was so prepared the kids she was pretty much the perfect teaching strategies for the National Science Education Standards like she was like the model for that like it was perfect. Like we would talk about things in here and then I would go to class and observe her doing that with the class in field. Like it was like the exact same things we were doing in this class she was doing in there with the 5th graders (G5-S6).

The response below was very representative of the views of the majority in the focus groups and indicates that preservice teachers are using their understanding of inquiry and inquiry-based pedagogy to overcome their apprehension about teaching science:

> I think that because science is a naturally curious subject that instead of having the teacher explain everything verbatim you know just lecturing all the information to you, inquiry allows you to just make your curiosity like learning from your curiosity instead of just asking questions and um sort of finding out the information yourself. (G3-S5)

Preservice teachers' responses show that they developed into reflective thinkers and were able to discriminate between teaching strategies they would and those they would not use during their own teaching This ability to discriminate between teaching strategies that work and those that do not work, in itself is learning that will help preservice teachers develop their own pedagogy in science or other subjects.

Thus, not only did preservice teachers receive good exposure to inquiry-based science pedagogy from the science methods course and the science field experience, this exposure helped them start formulating their own pedagogical strategies for teaching science. This latter finding indicates that preservice teachers had started conceptualizing their own pedagogical science strategies.

When asked to reflect back on what particular attributes of inquiry-based teaching they observed in the science methods course and the science field experience had helped them develop their own pedagogy in science, preservice teachers indicated that the key elements of inquiry-based teaching that they had internalized included: use of operational questions or discrepant events to stimulate student thinking and inquiries, learning through social interaction where students work in groups, provide feed back to each other and learn from each other, and having students involved in inquiry-based activities that are more student centered than teacher centered. These views expressed by the preservice teachers indicate their understanding about the five essential features of classroom inquiry as articulated in the responses below:

> I think we learned like what questions the students will ask (G4-S4)
> Starting the class with thought provoking questions to get the students in their thinking mood. (G1-S2)
> Have students discuss their observations….in this way we became the teachers!!(G1-S5)
> Having students work in groups. Most people believe that working in groups could be disruptive, but I found that the group helped pull me along when I was falling behind. (G1-S2)
> Leaving interesting stuff on the table and asking students to figure out what is was and what was going on. (G1-S3)

In addition, the preservice teachers indicated that they would use and have a lot of resources available to teach science through inquiry such as models, videos, whiteboards, posters and science notebooks.

Section II Summary

The analysis of the data presented in Section II from the preservice teachers' reflections captured through the focus groups and the confirmation of their responses through the transcripts of interviews with the science methods instructors and the SSQ supports the following findings:

1. Elementary preservice teachers report little or no exposure to inquiry-based science pedagogy prior to enrolling in the science methods course and science field experience at the University of Missouri- Columbia.
2. Elementary preservice teachers' understanding of the fundamental abilities, concepts and value of inquiry-based science instruction for learning of science evaluated through their reflections on focus groups and from the SSQ indicate that their vocabulary and understanding of abilities and concepts associated with

inquiry is consistent with the NSES recommendations for science as inquiry for grades K-4 (see chapter one).

3. Elementary preservice teachers report that learning science through inquiry, though frustrating at first, gave them an appreciation of the value of inquiry-based instructional strategies for making learning science fun and for keeping students involved, interested, confident, and responsible for their own learning.
4. Preservice teachers report their intent to use inquiry-based instruction to teach science in their own classroom after concurrently completing the science methods course and the science field experience at the University of Missouri-Columbia.

The findings from the analysis of data in this section support the following assertion: After concurrently completing the science methods course and the science field experience at the University of Missouri Columbia, the elementary preservice teachers' reported good understanding about the two key dimensions identified by the NSES for science as inquiry namely, the fundamental abilities necessary to conduct inquiry, and the fundamental concepts about scientific inquiry for grades K-4.

Thus, the findings from this section directly answer research question 2 namely: What do elementary preservice teachers report regarding their understanding of inquiry and inquiry-based science instruction after completing the science methods course along with the science field experience at the University of Missouri- Columbia?

Section III Analysis of Data in Support of Research Question 3

This section contains analysis of data pertaining to preservice teachers' confidence to teach science guided by the following research question:

Research Question 3:

What do elementary preservice teachers report regarding their confidence (self-efficacy) to teach science after concurrently completing the science methods course and science field experience at the University of Missouri- Columbia?

The category of meaning that pertains to research question is: Confidence to Teach Science. Three sources of data collection were used to answer this research question, namely Study Specific Questionnaire, STEBI-B survey, and preservice teachers' reflections on the focus groups.

Confidence to Teach Science

There was concurrence among the preservice teachers that the science methods course had given them the confidence to do science as inquiry and more importantly the confidence to teach science through the use of inquiry-based instructional strategies. This is illustrated by their responses below to the question about the effect of science methods course on their confidence to teach science as articulated in the responses below:

> I feel that it has increased my confidence to teach science just because I didn't really know a lot about how to teach science. I mean mostly what I thought about when teaching science is I would think back to elementary school and I remember doing a few, little, small experiments and then talking about the results and that's pretty much what it consisted of but in the class it taught that its more than just about experiments. It's about anything that you inquire about and asking questions and probing minds (G5-S5).

> "I had never experienced hands-on science. The methods course taught me how science can be made fun. The teaching strategies used in the methods course helped me with my confidence." (G1-S1)

> My confidence has increased because I had not really ever seen science taught the way the methods course taught. I had a lot of misconceptions." (G1-S2)

The above responses indicate that preservice teachers' confidence to teach science was developed as a result of being taught how to teach science through inquiry through the science methods course and the science field experience.

One of the key reasons given by the preservice teachers for their increase in confidence to teach science, after exposure to science methods course and science field experience, was the reduction in their anxiety about their knowledge of science content or about not being able to answer all of the students' questions right away. Specifically, preservice teachers reported that learning inquiry-based pedagogies, through the science methods course and observing them in the field, had taken pressure off of them since they realized that they were not expected to have answers to all student questions right away, or be subject matter experts, instead they realized that they could facilitate learning through student discourse as illustrated by the responses below:

> I feel like I know more about being a facilitator because I thought I always had to have all the answers (participants are talking over each other, mumbled)…I don't know where was my thought going I totally lost it um…just because I can't teach something that I haven't experienced.(G4-S5)

> Because once everyone starts coming up with these questions like you think you know something and understand it but then like once you hear it presented differently or like someone asks a question about it its like well I never really thought about it that way and so I know when I get into my own classroom the kids are going to be the same way and my students are going to be asking questions like that and so I think it will definitely be a learning process for both my students and me but I don't think I'm gonna be afraid to admit to them that I don't always have the answers and that like we can figure it out together and so…..(G2-S4)

--Well and like with inquiry the teacher is more of a facilitator instead of standing up in front of the classroom and like lecturing and so that helps too because then the instruction is guided more by the students instead of purely by the teacher so its like more of a combined effort and so you really get the best of both and you really like get to know what the students want to know and what prior knowledge they have and then you get to build upon that or change and adapt it to their needs and what they want to know about and what they already know about (G2-S3)

The above responses indicate that the science methods course and the science field experience had introduced preservice teachers to the new role of the science teacher namely, that of a facilitator of knowledge construction instead of the conventional role of the subject matter teacher teaching science from the text. Preservice teachers reported being comfortable with their new role as facilitators of learning, and as a result felt confident to teach science. Specifically, they indicated that learning with inquiry taught them that as teachers they do not have to be subject matter experts or provide answers to all student questions right away. Instead they indicated that the science methods course had taught them that they could facilitate students to find the answers through their inquiry as articulated in the responses below:

"……..Some of the things we learned was that like don't be afraid to say I don't know because you can just write the questions down and discover it with your class" (G2-S1)

Yeah! And its way better to admit you don't know something than to give them the wrong impression (muffled) (laughing) because like we've seen videos and people have like wrong totally preconceived notions about all these different things and their not right but people just think that they are that way because that's what they've heard and they've never really investigated it to find out if that's the truth so…(G2-S2)

The above responses indicate that preservice teachers felt that with the use of inquiry-based pedagogy they did not need to worry about their weakness of science content knowledge. This assumption of the preservice teachers is not accurate as literature indicates that both science content knowledge and science pedagogical content knowledge are needed to teach science (Darling-Hammond & Youngs, 2002). Literature also indicates that most elementary preservice teachers lack self-efficacy because of insecurity about their knowledge of science content (Cantrell, Young, & Moore, 2003; Hayes, 2002; Weiss, 2001; Downing & Filer, 1999; McLoughlin & Dana, 1999).

By using phrases like' I want to teach', 'previous to this I would be all upset when it was science time ….but now…..makes me feel a lot more confident …' or 'it's made me more confident…I changed my view of what to expect from methods course' all indicate a positive endorsement of the science pedagogical training received by the preservice teachers through the methods course and the science field experience as illustrated below:

> --um I think this class has made me more confident in like knowing how I want to teach science um I don't know the same thing that we've been saying, just having students figure out things on their own and then just discussing uh so I think that's the benefit that I'll take away and if its made me more confident then….but like I have always had the confidence to teach science because like math is not my best subject so I'm less confident teaching math than science. (G3-S3)

Preservice teachers reflected on their experiences in science content courses in high school and reported that they did not enjoy their science content classes and as a result were not comfortable teaching science. However, they reported being more positively disposed to teaching science after completing the science methods course at the University of Missouri-Columbia as indicated in the responses below:

> "I understand now that it's more about how to teach it rather than the specific content. That will come." (G3-S3)

> Um I definitely feel much more comfortable teaching science now; I am not a science person so I am opposite. I um can remember one specific

> grade that had my favorite teacher in it that I remember liking science and then middle school, high school and every other grade it never clicked with me and I've actually really been enjoying some of the things we've been doing in here and I think that is like key now that like I know how to do things so that I will enjoy it that will reflect or that the kids can pick up on that and hopefully pick up on that as well. Um not saying that previous to this I would be all upset when it was science time during the day but at least now I can find things that if they excite me that hopefully they'll excite my students and that makes me feel a lot more confident about teaching it. (G3-S2)

Preservice teachers credited the teaching strategies modeled in the science methods course such as: preparation of inquiry-based lesson plans, classroom discussions on inquiry, NSES recommendations for learning and teaching science through inquiry, questioning strategies for spurring student investigations, moving towards inquiry-based student centered learning as opposed to learning from the text, for developing their confidence to teach science as articulated in the response below:

> I would say mine has increased um like by doing lessons and talking about inquiry and things like that I think I kind of have a better idea of what to do instead of just saying okay open your book to this page like kind of how to introduce a lesson and to make it fun and to make students want to do it instead of like okay this is what we're going to learn about today and you need to take note…" (G2-S5)

> "It improved my confidence because it showed me where to get resources for science" (G1-S5)

The above response indicates preservice teachers gained confidence to teach science through exposure to inquiry-based teaching strategies.

Self Doubt and Desire for Stronger Content Knowledge

Even though majority of the preservice teachers indicated that they had developed confidence to teach science as a result of the science methods course, and even though they understood that they do not have to have answers for all student questions as these can be arrived through student exploration and discussions, some of them still felt insecure about their own ability to teach science as illustrated by the responses below:

> Yeah, I'm a little nervous about that (G4-S3)
> I would just say getting closer to student teaching and just this end part as we've done the lesson plans and like seeing activities that we've actually used I just think its getting closer to like when we're the actual teachers so um just that for me this class has been very frustrating for me at time. (G3-S4)
>
> I mean I guess we could all probably do a lesson on magnets, electricity because we've learned that, (yeah, yeah consensus) but there's all this other stuff out there and like we had that stuff in physics education class so in this one it was like kind of repeated material and so it was like ummm (a lot of yeahs and laughing) we kind of already know this so maybe we should like think about other things. I guess we talked about like the planets and stuff so that was good but like we still don't know the phases of the moon (laughing and agreement yeah, uh huh) or the whole rotation of….that was just confusing. It is one of those misconceptions. (G2-S5)

Thus, the preservice teachers' insecurity seemed to be arising either from the insecurity about their knowledge of science content, or due to the realization that graduation was close and that as they move into practice they would be required to implement the science teaching strategies in the classroom on their own. The feeling of insecurity about their ability to teach science is not unusual given the fact that preservice teachers were moving away from the protected environment of their science methods course where their instructors and classmates were available to help them, to an independence where they would have to implement inquiry themselves.

Some preservice teachers reported that their insecurity about teaching science was arising from their weakness in science content and indicated that they would be more comfortable teaching science if they could improve their science content knowledge as stated in the responses below:

“I don’t feel that I really learned any science content. I think my confidence would increase if I knew more content in science. (G1-S1)

> -- I feel like I could teach it but I feel like I don’t know a lot about yet the content and I also feel more comfortable with the younger grades because its like you know the basic stuff (Consensus yeah!) (Laughing) But you know we’re not getting too complicated yet, but when you move up in grades it gets more complicated. (Laughing) (G2-S5)
>
> I guess I am more confident because like I know how to approach teaching science. I’m not sure about like the actual concepts though…like if a kid asked me something about the moon I’d be like I would have no clue like it depends on what it is but like (laughing) “how does the sun rotate” like I would have no clue (laughing) like there’s just some weak parts like I was never really bad at science but I was never really good at it, so its like ummm I’m not sure if I would know everything but then again I know that asking, you know having them ask questions is good, I know that experimenting hands on is good, you know I know the approach I just don’t know if I know the content (G2-S3)

Thus, the above responses indicate that even though the preservice teachers were comfortable with inquiry and inquiry-based pedagogy, some were insecure about teaching science. Their main anxiety about teaching science was coming from the realization that they were weak in science content knowledge. This finding is consistent with reports in literature that one of the reasons for lack of science self-efficacy for elementary preservice teachers is their insecurity about science content (Cantrell, Young, & Moore, 2003; Hayes, 2002; Weiss, 2001; Downing & Filer,1999; McLoughlin & Dana, 1999). Accordingly, preservice teachers reported being comfortable teaching science in lower elementary grades but worried about teaching science to the upper elementary grades.

Even the preservice teachers who were insecure about their ability to teach science indicated that the science methods course had re-installed their confidence to teach science primarily by exposing them to inquiry-based teaching and learning as articulated in the responses below:

> “At first I would just go to the textbook for information. Now I am motivated to go out and use other resources to find the information I need” (G1-S6)
>
> My confidence has increased because I was definitely apprehensive about teaching science at first. I could always understand science but I just did not like it. This semester has been good because we have been shown other ways to teach science besides just using the textbook. Previously I thought it was about reading a textbook and following steps in a procedure and recording data (G1-S3)
>
> My confidence has increased. Before this I would have just followed the steps in the Teacher’s book in science that is on the sides of the pages in the book. Now I know other ways to teach science and make it more fun for the students and for me. I have learned different strategies so I feel like

The above responses indicate that exposure through the science methods course to inquiry-based instructional strategies, preparation of inquiry-based lesson plans, and availability of multiple instructional resources for planning inquiry-based science lessons, moved preservice teachers’ dependency from teaching science using the text to using inquiry-based activities which helped them develop confidence to teach science. Thus the preservice teachers reported that the science methods course positively influenced their confidence to teach science

Most of the preservice teachers reported that learning to teach science through inquiry had renewed their confidence to teach science. Specifically, they indicated that their initial thought was that it would be hard to teach science using inquiry in schools, given the current set up in elementary schools where teachers teach multiple subjects and not enough time is allocated for teaching science through inquiry. However, most indicated that after being taught with inquiry-based strategies, doing inquiry in the science methods course, and preparing inquiry-based lesson plans they felt more confident about managing their classroom time to include inquiry-based science activities as indicated by the response below:

> Also just that its possible, like I think that in a lot of schools for teachers if you think like oh you're going to have an experiment day in science in your classroom I think it could be kind of hard, but just being able to do especially the last couple weeks forming our own lessons has really just made it seem that its possible and its really not that hard at all like its definitely something that's doable and its something that I will try to incorporate for sure in my classroom (G3-S4)
> --- now I know like exactly like what websites I can go to get help you know what resources I can use (G3-S4)

The assertion that emerged from the above data is as follows:

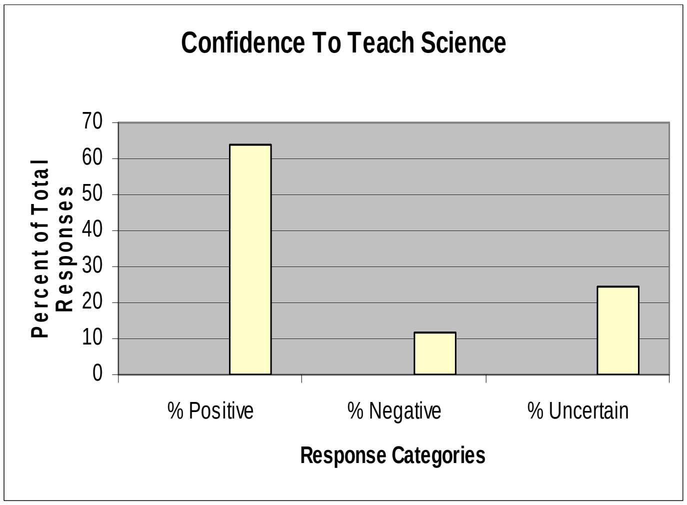
> *Elementary preservice teachers indicate having confidence to teach science after successfully completing the science methods course along with its field component, at the University of Missouri Columbia.*

This assertion was confirmed through the quantitative data generated by the analysis of preservice teachers' responses on the STEBI-B survey (Appendix C) and the SSQ (Appendix D) capturing preservice teachers' confidence to teach science. A total of forty students responded to the surveys from SSQ and STEBI-B instrument. Table 11and Figure 3 lists the results from the SSQ on the dimension capturing preservice teachers' confidence to teach science. These results show that while majority of the preservice teachers indicate having confidence to teach science, a small percentage (11.7%) of them were either negative indicating lack of confidence to teach science, and a small but significant percentage (24.6%) of them were unsure indicating their apprehension to teach science.

Table 10: SSQ: Preservice Teachers' Confidence to Teach Science

Response Category	**Percent Score**
Positive	63.8%
Negative	11.7%%
uncertain	24.6%

Figure 3: SSQ: Preservice teachers' Confidence to Teach Science



The STEBI-B instrument was used exclusively to capture the preservice teachers' confidence to teach science after concurrently completing the science methods course and the science field experience. The two dimensions measured using this instrument were the preservice teachers' personal science teaching efficacy (PSTE) and their personal science teaching outcome expectation (STOE). These dimensions taken together represent the preservice teachers' efficacy or confidence to teach science (Enochs & Riggs, 1990).

Table 12 below and Figure 4 show the results obtained from STEBI-B on the PSTE dimension. The results show that a (75.5%) of preservice teachers are positive regarding their personal science teaching efficacy indicating their confidence to teach science and only 7% were negative indicating not having the self efficacy or confidence to teach science while 17.5% were unsure indicating their apprehension about their ability to teach science.

Table 11: STEBI-B: Personal Science Teaching Efficacy (PSTE)

PSTE- Scores

%Positive	%Negative	%Uncertain
75.5	7	17.5

Figure 4: STEBI-B: Personal Science Teaching Efficacy (PSTE)

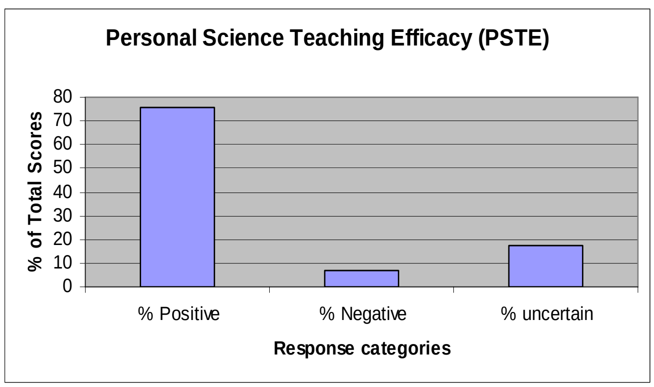


Table 13 and Figure 5 indicate the results obtained on the dimension measuring preservice teachers' science teaching outcome expectancy (STOE) using the STEBI-B instrument. Results on this dimension indicate that a majority (60.7%) of the preservice teachers were positive regarding the ability of teachers to influence learning of science. However an unusually large number also indicated being uncertain (27.8%).This latter result taken together with those respondents who responded negatively on this dimension

(11.5%) would suggest that a sizable number of preservice teachers (39.3%) were not sure how much influence teachers can exert on student learning

Table 12: STEBI-B: Science Teaching Outcome Expectancy (STOE)

STOE- Scores

%Positive	%Negative	%Uncertain
60.7	11.5	27.8

Figure 5: STEBI-B: Science Teaching Outcome Expectancy (STOE)

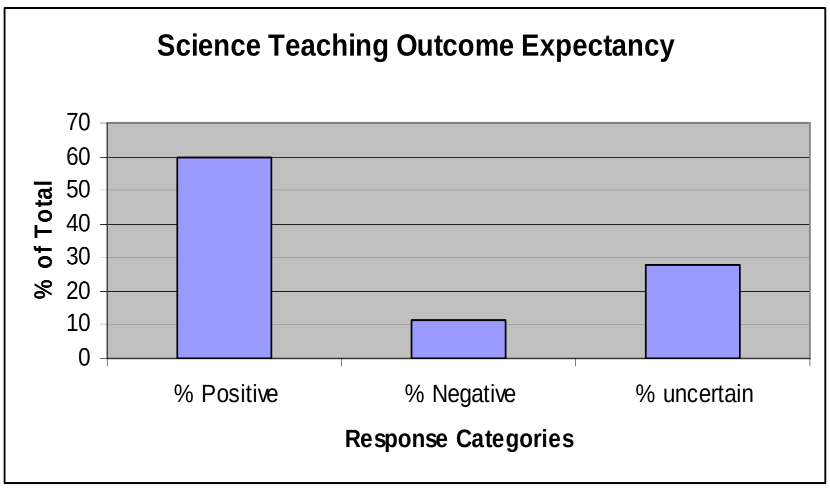


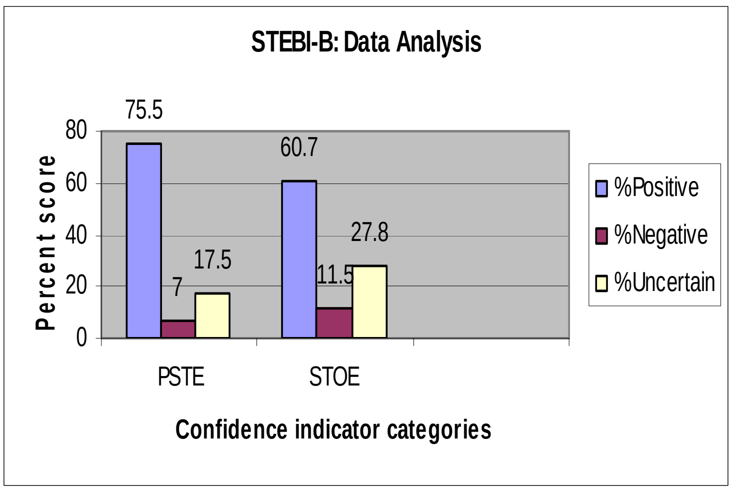
Table 14 and Figure 6 summarize the results for the two dimensions PSTE and STOE measuring the confidence of preservice teachers to teach science.

Table 13: STEBI-B: Confidence Indicator Dimensions

STEBI-B- Scores

	%Positive	%Negative	%Uncertain
PSTE	75.5	7.0	17.5
STOE	60.7	11.5	27.8
Confidence	68.1	9.3	22.7

Figure 6: STEBI-B: Confidence Indicator Dimensions



Results from STEBI instruments indicate that overall a majority of preservice teachers (68. 2%) indicate confidence to teach science. This data along with the data from the SSQ where 63.8% of the respondent preservice teachers indicated being confident to teach science and the data from the focus groups together indicate that majority of the preservice teachers in this study reported confidence to teach science after completing science methods course and science field experience at University of Missouri-Columbia.

What is interesting is that a comparable percentage of respondents on the two survey instruments (36.3% on SSQ and 22.0% on STEBI-B) indicated being either not sure or negative about their ability to teach science. Of the two dimensions captured via the STEBI-B instrument, the uncertain/negative scores are higher for STOE (19.6%) than for PSTE (12.3%) indicating that about 19.6% of the preservice teachers were apprehensive about whether teachers could influence learning while 12.3% were apprehensive about their own ability to teach science. This finding is not surprising as according to Bandura (1997) people develop a generalized expectancy concerning action-outcome contingencies based on their own life experiences. It is possible that these preservice teachers had had negative experiences in science classes which might have influenced their PSTE and STOE scores. There were a number of preservice teachers in the focus groups who indicated that they did not like science because they had not had good experiences in their science classes at high school.

Section III Summary

Analysis of data presented in the above section indicates that even though some preservice teachers reported not being confident with their knowledge of science content, majority reported being confident about teaching science. This confidence was a result of the inquiry-based instructional strategies they observed in the science methods course and in the science field experience. This is because they felt that the changing role of the teacher to a facilitator, allows them to facilitate learning rather than be subject matter experts. Thus their concern about not having answers to all student questions in science was alleviated with their exposure to inquiry-based science instruction. Preservice teachers reported feeling comfortable with teaching science through inquiry instead of teaching from the text. Thus, the preservice teachers reported that the inquiry-based teaching strategies used in the science methods course and the science field experience moved them from a dependency on teaching from the text to using inquiry-based and hence gave them confidence to teach science. The assertion emerging from the data presented in Section III (focus groups, interview transcripts, SSQ, and STEBI-B) is as follows:

> *Elementary Preservice teachers indicate having confidence to teach science after successfully completing the science methods course and its associated science field experience at the University of Missouri-Columbia.*

This assertion addresses the research question 3 namely:

> *What do elementary preservice teachers report regarding their confidence (self-efficacy) to teach science after completing the science methods course and science field experience at the University of Missouri-Columbia?*

Chapter Four Summary

The findings from this study show that elementary preservice teachers enrolled in the science methods course and the science field experience at the University of Missouri-Columbia in winter 2006, reported receiving little or no exposure to inquiry prior to the science methods course but received extensive exposure to inquiry-based teaching strategies through the science methods course and science field experience. Evaluation of the course materials and syllabus indicates that the intended curriculum and the delivered curriculum familiarized preservice teachers with the abilities necessary to conduct scientific inquiries and understanding of the concepts of scientific inquiry. These experiences ranged from structured, guided, to open, full inquiries encompassing all the five essential features for classroom inquiry identified by the standards. Interview transcripts indicate that the instructors used multiple instructional strategies to teach science and inquiry such as: questioning techniques for initiating inquiries; preparation of lesson plans and curriculum encompassing inquiry; review and class discussions of the NSES recommendations for science as inquiry; use of the 5E Learning Cycle instructional model which encompasses all the five essential features of classroom science inquiry outlined by the NSES; preparation and presentation of inquiry-based lesson plans incorporating NSES recommendations for science as inquiry; evaluation of instructional material for adequacy to teach science as inquiry; and use of assessment strategies specifically designed to gauge understanding of science concepts and inquiry.

Data from the focus groups confirmed the preservice teachers' exposure to multiple inquiry-based activities through the science methods course and inquiry-based pedagogy through both the science methods course and the science field experience. The preservice teachers' responses on the focus groups also indicated their understanding of the abilities required to conduct inquiry and the key concepts about classroom inquiry. Data from the SSQ confirmed preservice teachers' understanding of inquiry-based pedagogy, similarities between teaching strategies modeled in the science methods course and those observed in the field. The focus group transcripts, interview transcripts and the SSQ also indicated preservice teachers' confidence to teach science after concurrently completing the science methods course and the science field experience at the University of Missouri-Columbia. This finding was further confirmed through the findings from the STEBI-B instrument. The results fro the STEB-B survey showed that majority of preservice teachers rated highly on their personal science teaching efficacy (PSTE) and their personal science teaching outcome expectation (STOE) indicating their confidence to teach science. The findings indicate alignment of the intended curriculum with the delivered curriculum and the received curriculum for the science methods course at UMC, winter 2006.The three assertions/themes that emerged from the data in this study are as follows:

1. Inquiry-based science teaching and learning strategies recommended by the National Science Education Standards are integrated / emphasized in the science methods course at the University of Missouri- Columbia.
2. After concurrently completing the science methods course and the science field experience at the University of Missouri Columbia, the elementary preservice teachers' indicate understanding about the two key dimensions identified by the NSES for science as inquiry namely, the fundamental abilities required to conduct inquiry, and the fundamental concepts about teaching science as inquiry for grades K-4 and inquiry-based science instruction to teaching and learning science.
3. Elementary preservice teachers report confidence to teach science after successfully completing the science methods course and its associated science field experience, at the University of Missouri Columbia.

Each of these assertions directly answers the following three research questions posed in this study:

1. In what ways are inquiry-based science teaching and learning strategies recommended by the National Science Education Standards integrated/emphasized in the science methods course at the University of Missouri- Columbia?

2. What do elementary preservice teachers report regarding their understanding of inquiry and inquiry-based science instruction after completing the science methods course along with the science field experience at the University of Missouri- Columbia?
3. What do elementary preservice teachers report regarding their confidence (self-efficacy) to teach science after completing the science methods course and science field experience at the University of Missouri- Columbia?

Thus, this research successfully answered the research questions posed in the study.

CHAPTER FIVE

The purpose of this research study was to answer the following three research questions the study was designed to address:

1. In what ways are inquiry-based science teaching and learning strategies recommended by the National Science Education Standards emphasized or integrated in the science methods course at the University of Missouri-Columbia?
2. What do elementary preservice teachers report regarding their understanding of inquiry and inquiry-based science instruction after concurrently completing the science methods course along with the science field experience at the University of Missouri- Columbia?
3. What do elementary preservice teachers report regarding the effect, if any, on their confidence (self-efficacy) to teach science after concurrently completing the science methods course and science field experience at the University of Missouri- Columbia?

The overreaching question that guided the data collection, data analysis and organization of the findings in this study was: what do preservice teachers report regarding their understanding of inquiry-based pedagogy and their confidence to teach science after concurrently completing the science methods course and the science field experience at the University of Missouri-Columbia (UMC)? Therefore the primary data used to develop categories of meanings was the preservice teachers' perceptions captured through the focus group discussions. Nine categories of meaning emerged from the data.

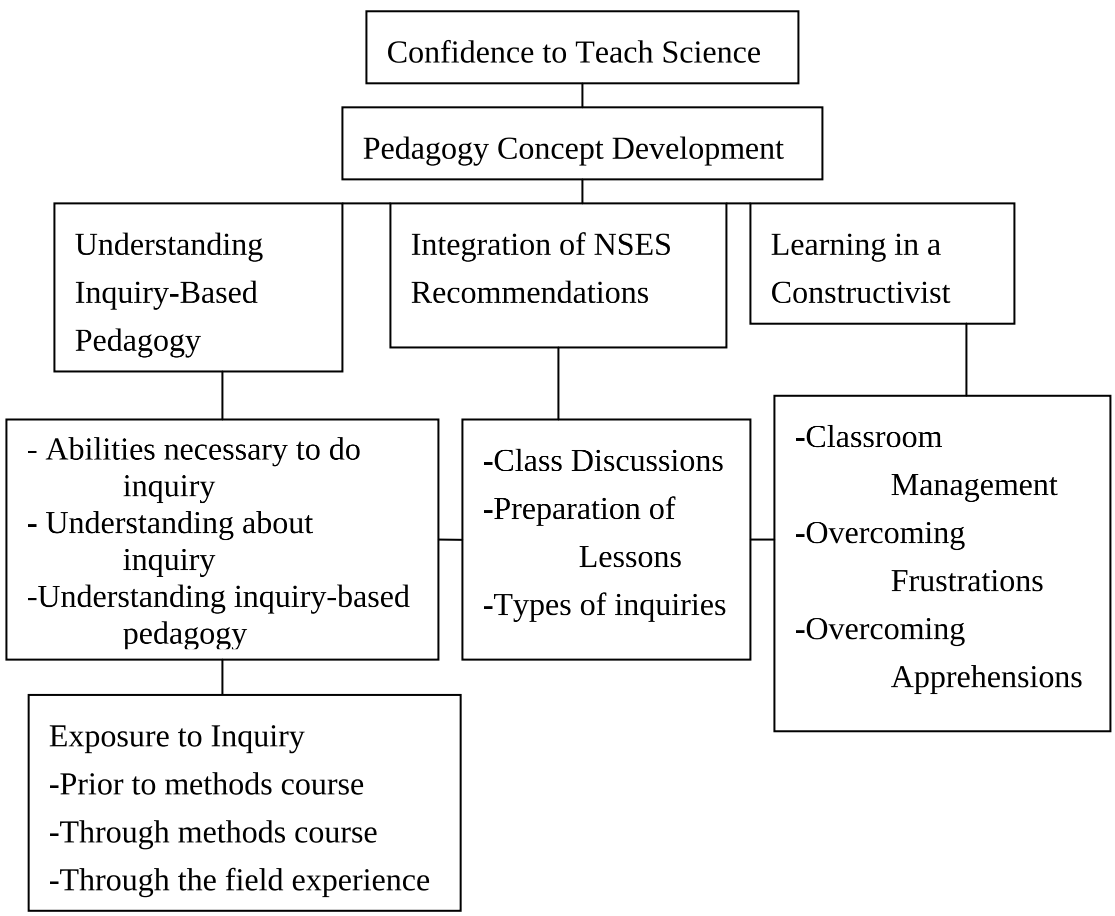
Each of these categories of meaning was used to formulate sub questions for analyzing data from the five data collection sources namely: (1) preservice teachers' focus group transcripts, (2) transcripts of interviews with the instructors teaching the science methods course at the UMC, (3) science methods course syllabus analysis for conformance to NSES recommendations for teaching and learning science through inquiry for K-4, (4) preservice teachers responses on the STEBI-B instrument measuring the preservice teachers' confidence to teach science, and (5) preservice teachers responses on the Study Specific Questionnaire capturing the preservice teachers' perceptions regarding their understanding of inquiry, confidence to teach science, and the similarities between the instructional strategies modeled in the science methods course and those observed in the science field experience.

This chapter consists of (a) discussion of findings with regard to the literature reviewed in Chapter 2, (b) a conclusion explaining how the study adds to the literature regarding the preparation of preservice teachers to teach science as inquiry after concurrently completing the science methods course and the science field experience, (c) limitations of the study regarding the applicability and generalizability of the findings, (d) implication of the study for educators and college teaching faculty involved in the preparation of elementary preservice teachers, and (e) recommendations for future research. To structure this chapter, I revisited Chapter 1 (Introduction-Statement of the Problem), Chapter 2 (Study Context-Review of Related Literature), and Chapter 4 (Findings).

Discussion

The main constructs evaluated in this research study were preservice teachers: (1) understanding about inquiry-based pedagogy, (2) their confidence to teach science, (3) understanding the NSES recommendations for doing science as inquiry. There were a number of categories that emerged from the data and are related to each of these constructs that arose from the data which were directly related to each of these main constructs. Relationships between the constructs and categories are outlined in the concept diagram below. In the discussion that follows, I discuss each of these constructs.

Figure 7: Concept Diagram



Integration of NSES Recommendations

Results of this study show that the recommendations of the NSES to learn and teach science as inquiry were taught (integrated) through the use of teaching strategies specifically geared to develop preservice teachers' abilities necessary to do scientific inquiry, understanding about scientific inquiry and science concepts and understanding of how to teach science through inquiry.

One of the key recommendations of the NSES is that teachers of science use "different strategies to develop the knowledge, understandings, and abilities described in the content standards" (NRC, 1996, p. 23). Review of the intended curriculum (syllabus and course materials), the delivered curriculum (instructional strategies and interview responses of the instructors), and the received curriculum (preservice teachers' reflections in focus groups and responses on the surveys) for the science methods course at the UMC in winter 2006 semester, indicates that several instructional strategies were used to teach science concepts, abilities and understanding about classroom inquiry, namely:

1. Designing multiple inquiry-based experiences
2. Guiding and focusing student inquiries instead of lecturing
3. The use of instructional models (5E) encompassing the five essential features of classroom inquiry outlined by the NSES.
4. Use of operational, scientifically oriented questions to initiate student investigations
5. Classroom discussions on inquiry-based science teaching and learning.
6. Development of lesson plans and curriculum integrating NSES recommendations for teaching science as inquiry.

7. Use of science notebooks for data collection and reflection.
8. Evaluation of instructional material for suitability to teach science as inquiry.
9. Assessment strategies to evaluate the understanding of science rather than the recall of facts.

All of the above teaching strategies are consistent with the recommendations of the NSES for facilitating students' understanding of NSES recommendations, developing student abilities to do inquiry, developing student understanding about scientific inquiry, and teaching preservice teachers how to teach science through inquiry. For example, literature indicates that selection of the right instructional model to teach inquiry is important because it is believed that modeling of inquiry by teacher educators is critical to helping preservice teachers to understand inquiry and to commit to incorporating inquiry-based teaching strategies in their own teaching (Volkmann et al., 2005). The 5E Learning Cycle instructional model used by instructors to model science pedagogy is aligned with the five essential features for classroom inquiry articulated in the Standards and contributes to the teacher's "coherent instruction and the students constructing a better understanding of scientific and technological knowledge, attitudes, and skills" (Bybee, 1997, p 167).

It is interesting to note that the theoretical foundation for the 5E instructional model is based on the constructivist perspective that assumes a dynamic and interactive view of human learning (Piaget, 1975) which is consistent with the premise on which the NSES were developed namely: "Learning science is something that students do, not something that is done to them" (NRC, 1996, p.2). Thus, the use of the 5E instructional model is consistent with the NSES recommendations that any instructional model that organizes and sequences inquiry-oriented learning experiences for students can be used to teach science as long as it incorporates the essential features for classroom inquiry outlined by the Standards (NRC, 2000). The use of this instructional model helps preservice teachers develop abilities necessary to do inquiry and understanding of classroom inquiry and how to teach science through inquiry (Bybee, 1997).

The intended curriculum (syllabus), the delivered curriculum (teaching strategies) and the received curriculum (preservice teachers' perception and responses) all indicate that elementary preservice teachers were provided with several, concrete inquiry-based experiences in a constructivist environment, that required them to perform a range of inquiry-based science investigations, which challenged them to rethink their ideas of how science is learned and taught. The use of multiple inquiry-based activities is also consistent with the NSES expectation that student inquiry in the science classroom encompass a range of activities which provide a "basis for observation, data collection, reflection, and analysis of firsthand events and phenomena" or those that encourage "critical analysis of secondary sources-including media, books, and journals in a library" (NRC, 1996, p. 33). These experiences were important in teaching preservice teachers the five essential features of classroom inquiry (NRC, 2000) and the different types of classroom inquiries for doing science.

The use of guided, inquiries was geared to teach preservice teachers science concepts and abilities necessary to do classroom inquiry, while open inquiries were designed to teach understanding about science and classroom inquiry. This teaching strategy is consistent with the recommendations of the NSES that "guided inquiry can best focus learning on the development of particular science concepts" and the more open inquiries afford "the best opportunities for cognitive development and scientific reasoning" (NRC, 2000, p. 30). Thus, the intended curriculum and the delivered curriculum show the integration of NSES recommendations for key abilities necessary to do inquiry, understanding about classroom inquiry and understanding of science concepts. Specifically, the intended and the delivered curriculums fulfilled the key requirements of the NSE teaching standard A, namely that teachers of science plan an inquiry-based science program for their students and of NSE teaching standard B, that teachers of science guide and facilitate learning (NRC, 1996; 2000) and are consistent with recommendations in literature that science instructional activities should neither be completely didactic where the teacher transmits facts or knowledge to the student nor should they be completely discovery oriented where students discover targeted science concepts through their own experiences, but instead should initially involve guided investigations where the teacher selects a phenomenon of interest or a question that spurs students to investigate (Volkmann et al., 2005).

Operational questions or effective questioning strategies were used to teach preservice teachers how to help students think critically and to initiate inquiry-based investigations. This is consistent with the science classroom envisioned by the Standards, where "effective teachers continually create opportunities that challenge students and promote inquiry by asking questions" (NRC, 1996, p.33). The focus group transcripts (received curriculum) indicates that preservice teachers' liked the use of operational, scientifically oriented questions and considered this teaching strategy to be a very effective way of getting students to think critically and initiate inquiries. Preservice teachers explicitly reported their intent to use operational questions in their teaching of science.

Assessment strategies taught to the preservice teachers were geared to evaluating four major learning outcomes of inquiry-based science teaching outlined in the NSES namely, the conceptual understanding in science, abilities required to perform classroom inquiry, understanding about inquiry, and understanding how to teach science using inquiry. Specifically, the instructors used both formative and summative assessments such as observations during inquiry-based activities, evaluation of written preservice teachers' reflection and lab notebooks, evaluation of inquiry-based science lesson plans and curriculums put together by preservice teachers. This form of assessment that seeks to gauge understanding of preservice teachers for learning and teaching science through inquiry is consistent with the NSES recommendations that assessment in inquiry-based classrooms differ from the conventional multiple-choice or short answer questions in that it "takes a broader perspective on the rich learning" (NRC, 2000, p. 75). The received curriculum confirmed the use of formative and summative assessments.

Thus, the results of this study show that the science methods course syllabus and the teaching strategies, used by the science methods instructors at the UMC in the winter semester2006, address both categories of the general requirements for science as inquiry listed under the NSES content standards namely: the fundamental abilities necessary to do scientific inquiry, the fundamental understandings about scientific inquiry that students in grades K-4 should possess and how to teach science using inquiry in the elementary grades (K-4). Specifically, results of this study indicate that the teaching strategies recommended by the NSES were integrated into the science methods course syllabus for the winter 2006 semester at the University of Missouri-Columbia. Therefore, this study successfully answered research question 1 that guided this study.

Understanding about Inquiry

The main goal of this study was to capture the elementary preservice teachers' perceptions regarding their understanding about inquiry and inquiry-based science pedagogy after completing the science methods course and the science field experience at UMC. In the context of inquiry, preservice teachers' perceptions, regarding their understanding of inquiry and inquiry-based pedagogy, was evaluated in the area of the following three major learning outcomes identified for inquiry-based science: (1) NSES recommendations for the fundamental abilities necessary to do inquiry in grades K-4, (2) NSES recommendations for the fundamental understanding about classroom inquiry for grades K-4, and (3) knowledge of how to teach science using inquiry. The evaluation of elementary preservice teachers' understanding about inquiry and inquiry-based pedagogy in science using these three dimensions is consistent with findings in literature indicating that inquiry teaching must not be considered independently of scientific inquiry and inquiry learning as they are all interrelated and the teachers' understanding of science as inquiry and learning as inquiry are fundamental to their understanding about inquiry-based pedagogy (Anderson, 2002).

Exposure to Inquiry

Most elementary preservice teachers in this study indicated that they had not had any previous exposure to the inquiry-based science through their high school or college science courses and that their total exposure to inquiry form of instruction and learning was through the elementary science methods course. The few preservice teachers who recalled inquiry-based teaching exposure in their basic science courses e.g. physics course, indicated that at the time when they went through their science content course they did not recognize the teaching strategies as inquiry-based or did not realize the value of the teaching strategies being used. This finding is consistent with reports in literature that elementary teachers do not receive adequate preparation in the theory and practice of inquiry (Radford, 1998; Rutherford & Ahlgren, 1990; Hayes 2002). Recent surveys indicate that inquiry mostly remains unimplemented in most classrooms across the country (Weiss et al., 2001; 2003) because of the beliefs of teachers' being at odds with reform-based teaching (Volkmann et. al., 2005; Anderson, 2002), or because of lack of support from school administrations and time constraints on teaching science (Weiss, 2002; 2003).

These preservice teachers indicated that the concept of classroom inquiry and inquiry-based pedagogy was emphasized through the elementary science methods course at the UMC and that they drew connections to their earlier experiences with inquiry-based pedagogy only after exposure to classroom inquiry through the elementary science methods course.

Abilities Necessary to do Inquiry

The development of abilities necessary to do inquiry was done through participation in multiple types of inquiry-based activities. This teaching strategy is consistent with the recommendations of the NSES for grades K-4 (NRC, 2000). The delivered curriculum (interview transcripts) shows that guided inquiries spanning from partial to full inquiries were used to teach preservice teachers abilities necessary to do inquiry. This is consistent with NSES guidance that guided inquiries are used more for teaching science concepts and developing abilities necessary to do inquiry (NRC, 2000). The received curriculum (preservice teachers' reflections in focus groups and responses on the SSQ), indicates that that for majority of the preservice teachers' learning of abilities necessary to do inquiry were reinforced through the observation of inquiry-based activities in their science field experience. However there were a few students who did not observe science or inquiry-based pedagogy in the field either because their scheduled observation times did not coincide with science period or the mentor teacher was busy focusing on other priorites such as MAP testing. This finding is consistent with reports in literature that finding quality field placements for preservice teachers is a challenge for educators (Abell, 2006).In general, results of this study show the elementary science methods course and the science field experience helped preservice teachers develop abilities necessary to conduct inquiry.

Understanding about Inquiry

Preservice teachers' responses in the focus groups indicated their understanding of scientific inquiry. Specifically, their responses indicated their understanding that scientists try to understand the natural phenomena by conducting inquiry-based investigations, that the results of scientific investigations are reviewed with other scientists, that explanations of scientific phenomenon are examined in light of what is already known, that results obtained could raise more questions that could trigger more investigations and that currently held concepts or views about certain natural phenomena could change if new evidence becomes available. This understanding of preservice teachers is consistent with the NSES description for scientific inquiry that "scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (NRC, 1996, p. 23).

The intended curriculum, the delivered curriculum, and the received curriculum indicate that preservice teachers were taught understanding about inquiry in a number of ways. For example, their involvement in multiple scientifically oriented activities, the trip through the woods to investigate natural phenomenon, the formulation of explanations or design of experiments to explain discrepant events, were all geared towards developing preservice teachers understanding about inquiry and its value to learning science. The learning and understanding of inquiry through engagement in scientifically oriented experiences is consistent with the NSES explanation that "inquiry also refers to the activities of the students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (NRC, 1996, p.23).

The received curriculum (focus group transcripts and SSQ) indicates that preservice teachers' understanding about inquiry is consistent with the NSES recommendations for the fundamental abilities and the fundamental understandings that students in grades K-4 should have about scientific inquiry. Specifically, the results show that preservice teachers understand that learning science is an active process and that learners must be exposed to activities that engage them to answer scientifically oriented questions; that learning is something students do, not something that is done to them; or that to answer scientifically oriented questions learners make observations, gather data, develop explanations, evaluate, communicate and justify their explanations to their peers and that the abilities required to do scientific inquiry include cognitive abilities which go beyond what has been termed as 'process' skills such as observations, inference, and experimentation (NRC, 2000). Thus, embedded in the responses from the preservice teachers in the focus groups and their responses on the Study Specific Questionnaire, is their understanding of scientific processes and scientific investigations or their conceptual understanding about what constitutes scientific inquiry. According to Anderson (2002), this form of inquiry learning reflects the nature of scientific inquiry. Thus, the results indicate that preservice teachers understand scientific inquiry and learning through inquiry.

Understanding Inquiry-Based Pedagogies

Results from this study indicate that preservice teachers' exposure to inquiry-based pedagogies through the elementary science methods course and the science field experience helped them understand inquiry-based science teaching strategies. The intended, the delivered and the received curriculums indicate that preservice teachers learned inquiry-based pedagogy for teaching science through multiple avenues such as: participation in multiple inquiry-based activities, preparation of and teaching inquiry-based science lesson plans incorporating recommendations of the NSES for classroom inquiry, observing inquiry-based instructional strategies in the elementary science methods course and the science field experience, learning about instructional models (5E) that incorporate all five essential features of classroom inquiry outlined by the NSES, learning effective questioning strategies to initiate critical thinking and learning how to use them to initiate student questions and inquiries, learning how to evaluate instructional material for teaching science through inquiry, learning how to guide and facilitate student inquiries in class, understanding the new facilitator role of the teacher when teaching science through inquiry, understanding the value of inquiry-based pedagogy to student learning of science, and learning assessment strategies that can be used specifically for assessing deeper student understanding of science and inquiry. Not only did the preservice teachers report understanding how to teach science through inquiry, their reflections in focus groups indicate that they also understood the value of teaching science through inquiry. The benefits of using inquiry-based teaching strategies to learn science reported by the elementary preservice teachers in this study are consistent with the constructivist approach to learning and indicate the cognitive development of the elementary preservice teachers in the area of scientific inquiry and inquiry-based teaching strategies. For example, based on their personal experiences with inquiry-based activities in the method course, the elementary preservice teachers in this study indicated that inquiry-based instruction helps students develop into independent thinkers, gives students a sense of achievement and responsibility for their own growth as learners, sustains student knowledge since knowledge constructed through doing stays with the individual, provides learning through social interaction or sharing of ideas with peers and instills interest and confidence in students to do science. This latter understanding of the preservice teachers is important in that it indicates that not only did the preservice teachers understand the value of inquiry-based teaching for instilling confidence in the students for doing science, but they also understood that if students become confident and interested in science they might be encouraged to pursue scientific careers bridging the shortage of scientists in our society.

The depth of their understanding of the value of the inquiry form of science instruction was further indicated by the connections preservice teachers made to the use of the inquiry-instruction for other subjects and the use of inquiry method to investigate a crime scene, or resolve conflicts or to the analogy to the ‘Show Me’ motto for the state of

Missouri which in a way exemplifies what scientific investigations are about. This is an indication of their cognitive development in the area of pedagogy content knowledge for teaching science.

In short, the results of this study show that preservice teachers have an understanding about what constitutes scientific inquiry, the abilities necessary to do inquiry for students in grades K-4, the fundamental understanding about inquiry for students in grades K-4, how to teach science through inquiry and the value of inquiry-based science pedagogy to teaching and learning science. These findings answer research question 2 in that the results indicate that preservice teachers' understand the fundamental abilities necessary to do inquiry, the fundamental concepts about inquiry, and how to teach science using inquiry-based pedagogy and the value of inquiry-based teaching and learning of science for grades K-4 as articulated in the NSES (NRC, 1996).

Learning in a Constructivist Environment

The majority of the preservice teachers in this study welcomed the constructivist approach or a shift to inquiry-based pedagogy for teaching science. This is because they reported that the inquiry-based pedagogy allowed them to get away from the traditional textbook dependency as the main course of science information and transition to a more hands-on approach where students are central to the knowledge building and the learning process. They also reported that the use of inquiry-based learning can help students retain knowledge better than if they are taught using a textbook. This perception of preservice teachers is consistent with reports in literature that inquiry-based teaching strategies and a greater emphasis on inquiry methods for the development of personal meaning in science can lead to higher student achievement in science (Anderson, 1997; Von Secker, 2002;

Von Secker & Lissitz, 1999; Duran, McArthur & Hook, 2004). However, research also points out that unless students have opportunities to receive guidance as they investigate phenomena they will not develop abilities to perform inquiry, and therefore suggests that teaching strategies should neither be mostly didactic or mostly discovery oriented but instead should be somewhere in between these two extremes (Volkmann et. al., 2005). The teaching strategies used by the instructors in this study comply with this finding as the instructors in this study used the inquiry related approach spanning from guided inquiry where the teacher gives step by step directions to students on how to conduct inquiry, to an open inquiry where students struggle through on their own to conduct an investigation triggered by a probing question or a discrepant event supplied by the teacher (NRC, 2000).

Classroom Management

An unexpected but interesting benefit cited by preservice teachers of the constructivist approach to learning science was in the area of classroom behavior management. Preservice teachers indicated that students who are engaged in inquiry-based science would cause fewer classroom behavior management challenges. Specifically, preservice teachers felt that the inquiry form of instruction afforded opportunities to keep students interested and involved in their own learning and would perhaps lead to less classroom management problems. Though this is a logical conclusion based on the knowledge about learning in a constructivist environment, it is contrary to at least one finding in literature. Specifically, in a study conducted to evaluate preservice teachers' struggles to define inquiry-based science teaching, Hayes (2002) reported that when he discussed elementary preservice teachers' concerns about implementing inquiry with their students in their field placement, preservice teachers appeared to be worried about the possibility of discipline problems, and expressed concerns about maintaining control of the students during open explorations required for inquiry-based learning. Others have pointed out that concerns about classroom management are quite common for both preservice teachers and beginning teachers (Flick, 1997; Bullough, Knowles & Crow, 1992) and therefore might not be just specific to teaching with inquiry-based science. Similar concern was also articulated by the graduate student instructor of the science methods course in this study.

Overcoming Frustration of Learning in a Constructivist Environment

An interesting finding from this study was that initially most preservice teachers indicated experiencing frustration with the inquiry-based, constructivist way of learning. The preservice teachers stated that they wanted more direction from the instructors and were lost and frustrated without direction. However, almost everyone reported that after the initial frustration, towards the end of the elementary science methods course, they developed a new appreciation for the value of the inquiry form of science instruction for student learning and valued the active learning experiences and opportunities afforded to them by their instructors. Most preservice teachers complimented the hands-off approach taken by the instructors and indicated that this approach helped them construct their own knowledge thus confirming the NSES premise that 'children learn by doing' and that 'learning science is something students do, not something that is done to them'. This cognitive development of the preservice teachers is consistent with the constructivist theories and the development theory of Jean Piaget (1975) according to which "learning begins when individuals experience disequilibrium" or a discrepancy between "what they think they know and what they observe or experience" (NRC, 2000, p. 34) and that to bring their understanding back into equilibrium individuals need to "adapt or change their cognitive structure through interaction with their environment" (NRC, 2000, p. 34).

The finding that preservice teachers moved from initial feeling of frustration in a constructivist learning environment to a feeling of acceptance and appreciation is also consistent with results reported in literature for specialized inquiry-based science content courses. For example, after exposure to a specialized inquiry-based biology course, researchers report that preservice teachers moved through an initial feeling of hesitation to gaining improved confidence and self efficacy (Friedrichsen, 2001) in biology. Preservice teachers participating in a redesigned inquiry-based chemistry course to help them develop pedagogical content knowledge, initially reported concerns as they adjusted from a traditional course to an inquiry-based course, but at the conclusion of the course reported that they felt better prepared to teach chemistry (Jones et al, 1997). A similar shift from discomfort to appreciation with the constructivist approach to learning science was expressed by preservice teachers enrolled in a specialized astronomy course (Powell, 2003). Preservice middle childhood teachers enrolled in an inquiry-based specialized undergraduate physics course moved from initial frustration to embracing the inquiry form of learning in the constructivist environment (Duran, McArthur& Van Hook, 2004). Similarly, preservice teachers in a specialized experimental inquiry-based science course indicated that the course improved their pedagogical and content knowledge and was relevant to their development as future science teachers (McLoughlin & Dana, 1999). In another study designed to evaluate students' experiences in an inquiry-based undergraduate physics course, students experienced frustration with the inquiry form of learning. However, despite their frustrations as learners, they "connected events of questioning, predicting, observing and explaining to scientific inquiry and held a positive view of the inquiry-based course as a model for future teaching" (Volkmann et al., 2004, p. 860). A study done to evaluate the struggles faced by preservice teachers to understand and implement an inquiry teaching unit in their field placement setting, revealed that though initially the preservice teachers struggled with the planning, maintaining control over student behaviors and the very assumptions of inquiry, their struggles resulted in helping them make sense of and defining the terms of inquiry (Hayes, 2002). Thus, the frustrations reported by the elementary preservice teachers in this study, and their final appreciation of the inquiry form of teaching and learning is consistent with reports in literature and shows that struggles of working through a learning experience in a constructivist environment brings about an understanding of inquiry and science concepts. It is therefore not surprising that some researchers are recommending that to teach inquiry to preservice teachers, science teacher educators should target the fundamental aspects of scientific inquiry and problematize them for prospective teacher learning (Haefner, & Zembal-Saul & Zembal-Saul, 2004).

Overcoming Apprehensions about Teaching with Inquiry.

Another interesting finding of the study was that even though the majority of the elementary preservice teachers indicated confidence to teach science after completing the elementary science methods course and the science field experience at the UMC, a small but significant number of preservice teachers indicated being apprehensive about their own ability to teach inquiry-based science. This is an interesting finding especially since the majority of preservice teachers reported having good exposure to inquiry-based pedagogy, understanding inquiry and the value of inquiry-based science teaching for learning science. Preservice teachers' apprehensions about teaching inquiry-based science were stemming from self doubt about their own knowledge of science content, from the knowledge that inquiry-based instruction in a constructivist environment is more time consuming and required additional effort and preparation time, and from their concerns about whether the traditional elementary school curriculum would provide adequate time or support for them to implement inquiry-based science teaching strategies. This feeling of doubt is consistent with findings reported in literature for a study which evaluated preservice elementary teachers' struggles with defining inquiry-based science teaching (Hayes, 2002). In this study when preservice elementary teachers were asked to reflect back on their experiences of implementing inquiry-based pedagogy in their field experience, they voiced concerns about inquiry-based teaching taking up too much time during the day and space in the curriculum and worried about "the possibility of discipline problems, exorbitant preparation requirements, and their lack of knowledge in a particular topic" (Hayes, 2002, p. 151).

Anderson (2002) points out that teachers considering new approaches to education, such as inquiry-based instruction, face dilemmas about change which many times are due to their own "beliefs and values related to students, teaching, and the purposes of education" (p.7). This contention is supported by Volkmann et al (2005) who too point out that doubts about teaching inquiry-based science could stem from preservice teachers' own beliefs, values, and goals being at odds with those that support inquiry.

Others point out that the current set up of the elementary school curriculum does not afford teachers time or the support for teaching science consistent with recommendations of the NSES for doing science as inquiry (Abell & Roth, 1992; Abell, 2006). Literature also points out that teachers work in complex social and intellectual environments that both enable and constrain efforts to change (Brickhouse & Bodner, 1992; Tobin & Lamaster, 1995).

Hayes (2002) found that the elementary preservice teachers' struggles to define and implement inquiry oriented practices were related to their inability to let go of the teacher's authority to control and direct student learning, their reluctance to go with student interests or to allow students to lead the curriculum, and their discomfort with establishing a form of reduced teacher control and authority in the classroom that was new to them. Research indicates that barriers and dilemmas relating to inquiry-based science instruction are clustered in three dimensions namely: the technical dimension, the political dimension and the cultural dimension (Anderson, 1996). According to Anderson (2002, p.8) the "technical dimension included limited ability to teach constructively, prior commitments (e.g. to a textbook), the challenges of assessment, difficulties of group work, the challenges of new teacher roles" for inquiry-based science. The political dimension includes among other things, "unresolved conflicts among teachers, lack of resources" etc (Anderson, 2002, p.8). Cultural dilemmas stem from teachers' beliefs and values and their perceived need to prepare students for the next grade level for which they considered the textbook the best tool (Anderson, 2002).

An important outcome of this present study is that even though some preservice teachers felt insecure about their science content knowledge, or realized that inquiry-based instruction would require more planning and class time, or that traditional school environments might not allow them to use inquiry-based science instructional strategies, they still felt confident that they had received the tools they required to manage their time to implement inquiry-based instruction. This is consistent with the finding in literature that even though preservice teachers struggle and experience anxiety about using inquiry-based pedagogy for teaching science, these struggles help them understand the nature and value of inquiry-based teaching practices. For example, in a study conducted to evaluate preservice elementary teachers' struggles with implementing inquiry-based projects in their field experience, Hayes (2002) found that the elementary preservice teachers struggled to implement inquiry, however after coming through their struggles, preservice teachers came to define and truly understand the nature of inquiry-based teaching (Hayes, 2002).

Personal Pedagogy Development

Research points out that most teachers usually struggle to construct their professional roles and identity as a particular kind of science teacher (Helms, 1998). For example, Volkmann & Anderson (1998) point out that the teacher in their study worked to negotiate the tensions between possible versions of science teacher identity, such as the caring teacher who nurtures students and the tough teacher who maintains control in the classroom. Similarly, Bryan and Abell (1999) in their research on preservice teachers developing professional knowledge, highlight one teacher's conflicts and struggles in developing her science teaching practice. Goodfellow & Sumsion (2000) point out that it is the struggles related to resolving these tensions in a meaningful way that lead preservice or novice teachers to come to grips with their emerging identities as teachers.

Literature points out that under the reform-based curriculum, construction of an identity as a science teacher can be complicated due to the multifaceted nature of inquiry science teaching (Colburn, 2000; Hayes, 2002). However, most preservice teachers in this study reported that the teaching strategies modeled and taught by the instructors and practiced by the preservice teachers in the elementary science methods course and observed through the science field experience were beneficial to them for developing their own teaching strategies for their future careers as practicing teachers. This is consistent with findings reported in literature that engaging preservice teachers' in scientific inquiry-based courses not only leads to the development of their understanding of science and scientific inquiry but that it also helps prospective teachers become more accepting of approaches to teaching science that encourage children's questions about science phenomena (Haefner, & Zembal-Saul, 2004). This has only been demonstrated in the context of an innovative life science course.

No studies until this present study had examined the elementary preservice teachers' perceptions regarding the development of their own pedagogy in science after completing the traditional elementary science methods course and the elementary science field experience. This gap in research is being addressed through this research study. The majority of the elementary preservice teachers in this study indicated that the teaching strategies observed in the field were consistent with those that were modeled or taught in the elementary science methods course and that these similarities helped them understand inquiry-based pedagogy for teaching science. This finding is consistent with reports in the literature that the utility of the field experience is enhanced when it is integrated into formal coursework (Pryor & Kuhn, 2004; Metcalf & Kalich, 1996).

The results of this study also indicate that observing inquiry-based pedagogy in the elementary science methods course and the science field experience gave preservice teachers insight into what teaching practices they would and would not adopt. For example, the preservice teachers were very accepting of the constructivist approach or inquiry-based pedagogy for teaching science as it alleviated their apprehension about teaching science, stemming from their insecurity about their science content knowledge and their fear of not being able to respond to all students' questions raised during inquiries. Specifically, with exposure to inquiry-based science pedagogies through the elementary science methods course, their view of teaching science changed from the traditional view, where teachers are expected to be subject matter experts and provide answers to all students' questions, to a view which is more consistent with contemporary reforms namely where teachers function as facilitators encouraging students to come up with answers and explanations to questions. This is in keeping with the NSES recommendations that teachers focus, and support student inquiries and intervene in the learning process to encourage, challenge, and focus students (NRC, 1996).Thus, the results of this study indicate that elementary preservice teachers felt comfortable in their new role as facilitators of science learning. This finding is consistent with at least one report in literature in which elementary preservice teachers initially struggled with the implementation of an inquiry teaching unit in their field placement but became accepting of the idea of inquiry, since it allowed them to begin thinking of working with children to generate ideas and questions specific to students' experiences (Hayes, 2002).

An important finding of this study is the elementary preservice teachers' understanding that when they persist through their initial feelings of frustration of doing open inquiries in a constructivist environment, they can develop better insight into the scientific concepts, better retention of learning, and improved self confidence to do science than when going through a traditional lecture based class. This insight into the value of inquiry-based learning was the key motivator in their intent to use inquiry-based pedagogy for teaching science in their own classroom. Specifically, based on their own experiences they felt that they would be able to use inquiry-based pedagogy to develop the students' interest in science and give them confidence to do science. Thus the results of this study suggest that frustration and struggle with the scientific inquiry-based pedagogical experiences for preservice teachers can be very effective means of learning about scientific process and science. This is consistent with research findings that students who deal with issues they are struggling with while doing inquiry show more learning than those who do not attempt to resolve their frustration but instead just drop the issues and move on (Haefner, & Zembal-Saul, 2004).

Confidence to Teach Science

An interesting benefit of the constructivist approach, or inquiry-based science teaching and learning strategies, cited by the preservice teachers was the inculcation of confidence in them to teach science and the realization that this form of science instruction can be used by them to instill confidence in their students to do science.

The indication of confidence to teach science by preservice teachers following inquiry-based experiences in the science methods course is consistent with the results obtained by Huinker & Madison (1997) in a study conducted to evaluate the impact of methods courses in science and mathematics on preservice teachers' personal efficacy beliefs and outcome expectancy beliefs in science. In this study the science methods course consistently had a positive influence on the elementary preservice teachers' beliefs in their ability to teach science. Similarly, in a study conducted by Morrell & Carroll

(2003) to examine the impact of science methods courses, student teaching and science content courses on elementary preservice teachers PSTE, researchers found significant gains in PSTE and attributed these gains to the education program design. Thus design of the methods courses is critical in improving preservice teachers' self-efficacy to teach science.

The predominant reason given by preservice teachers' for self-efficacy was the alleviation of their apprehension about their insecurity about science content knowledge and not being able to answer student's questions. This was alleviated through the recognition of their new role as facilitator which made them secure in the knowledge that they do not to provide answers to questions right away. This lack of fear or inadequacy of science content knowledge is consistent with reports in literature that elementary teachers do have enough training in science content (Weiss 2002, Wilson et. al. 2001; Morrell et. al., 2003; Cantrell, et. al., 2003).

In a study conducted by Cantrell et.al.(2003), to evaluate the self-efficacy of elementary preservice teachers, after a science methods course, researchers found that preservice teachers who had taken more than the required number of college science content courses had higher scores on STOE than those who took only the required science content courses. The researchers point out that this increase could be explained by the fact that the practice of teaching science caused the student teachers to draw upon their content knowledge most recently completed at the university and by doing so their outcome efficacy beliefs were positively impacted (Cantrell et.al., 2003).

Another reason given by preservice teachers for their confidence to teach using inquiry was the use of multiple inquiry-based teaching strategies by the instructors. For example, preservice teachers indicated that leading a science investigation with a question was an effective teaching strategy in science as it helped them through the cognitive processes of discovery and explanations and helped build confidence to teach science. This is consistent with Bandura's theory (1977) that the vicarious experiences where one observes another's performance gives confidence. Literature indicates that preservice teachers have vicarious experiences when they observe instructors modeling teaching strategies or mentors teaching a lesson in the field (Bleicher, 2006).

Other teaching strategy outlined by the preservice teachers that contributed to their confidence was the constant verbal persuasion from the instructors regarding the benefits of inquiry-based pedagogies to teach science. Most preservice teachers pointed out that they had abundant exposure to inquiry-based activities and pedagogy in the science methods course and that the instructors were very successful in "drilling inquiry" into their heads. These verbal experiences could have contributed to their teaching self-efficacy. According to Bandura (1986), people who are persuaded verbally that they possess capabilities to successfully perform given tasks are likely to put forth greater sustained effort, develop abilities consistent with expectations and gain self-efficacy.

Another key factor responsible for instilling confidence in the preservice teachers was the reinforcement of the inquiry-based pedagogy through field observations. Actually seeing reform based pedagogy in the field helped them put their theoretical understanding of inquiry-based pedagogy in the context of classroom teaching. According to reports in literature, alignment of field experience with the methods courses helps anchor theoretical concepts (Pryor & Kuhn, 2004).Also, in a study conducted to evaluate the efficacy beliefs of a sample of elementary preservice teachers at three stages of their program starting with the introductory methods seminar courses, followed by the advanced methods course, and finally at the end of their student teaching, Cantrell et. al. (2003) found that the largest increase in preservice teachers efficacy occurred after the field experience. Therefore, quality field experiences are critical to improving self efficacy.

A disturbing finding of this study was that a small but sizable number of elementary preservice teachers reported not observing science in their science field experience even though the science field experience at the University of Missouri-Columbia, is offered concurrently with the elementary science methods course to help teachers anchor their theoretical learning about science teaching strategies through the observation of science pedagogy in an actual school setting. At least 9.2 % of the respondents on the Study Specific Questionnaire responded negatively on the dimension eliciting information on similarities between teaching strategies modeled in the elementary science methods course and those observed in the science field experience while 19% of the respondents were uncertain. This finding is significant given the information in literature that a disconnect between course work and field experience can be a barrier to the understanding by the preservice teachers of how to frame theoretical explanations of classroom practice (Goodlad, Soder & Sirtnik, 1990; Beyer, 2001) and is consistent with reports in literature citing challenges faced by educators to arrange elementary science methods field experiences (Abell, 2006).Quality field experience is a key to learning how to teach as according to literature, understanding of how to teach is the foundation of development of effective teachers (Scherer,2001). Literature indicates that a disconnect between course work and field experience is a barrier to the development of the ability of preservice to frame theoretical explanations of classroom practice (Beyer, 2001).Therefore, the self-efficacy of these preservice teachers who did not get exposure to science in the field might be affected as according to Bandura (1981), self efficacy of individuals can be enhanced through modeling and successful mastery experiences such as those acquired through field experience. These preservice teachers would have been deprived of the mastery and vicarious experiences from the field which according to Bandura (1986) are two of the major contributors to a preservice teachers' self-efficacy.

Overall, the results of this study indicate that preservice teachers report being confident to teach science after concurrently completing the elementary science methods course and the science field experience at the UMC during the winter 2006 semester. This study successfully answered research question 3. However, what is not known is whether this confidence will lead these preservice teachers to use inquiry-based pedagogy. Majority of the preservice teachers in this study indicated their intent to use inquiry-based strategies to teach science in their classrooms. There is evidence in literature that a mathematics methods course can change preservice teachers' beliefs and attitudes to be more consistent with the current reform movement in mathematics (Wilkins & Brand, 2004). Therefore it is possible that these preservice teachers might implement inquiry in their classroom. However, this will need to be explored through a follow-up study.

It is important to point out that the data from the Study Specific Questionnaire shows that at least 24.6 % of the preservice teachers responding were negative about teaching science and that an additional 11.7% of the respondents were uncertain of their ability to teach science. The negative and the uncertain responses when taken together indicate that about 36% of the preservice teachers were apprehensive or unsure about their ability to teach elementary science. This same statistic is seen from the STEBI-B results which indicates that 25% (7% negative plus 18% uncertain) of the respondents were apprehensive about their personal ability to teach science while 40% (12 % negative plus 28% uncertain) were apprehensive about whether teaching can influence student learning outcomes. Since these two dimensions on the STEBI-B instrument are a measure of science teaching efficacy of the preservice teachers, taken together these results indicate that even though the majority of the preservice teachers report having the confidence to teach science, a sizable number felt apprehensive about teaching science.

This finding can be explained in context of apprehensions voiced by some preservice teachers about teaching inquiry-based science given the current set up of schools which might not afford them adequate time to prepare inquiry-based lessons, or enough class time and support from the school administration to implement inquiry. This apprehension is consistent with similar findings in literature for elementary preservice teachers implementing inquiry in the field (Hayes, 2002; Weiss, 2002). It could also be explained by preservice teachers' self efficacy beliefs being as odds with reform based teaching (Anderson, 2002; Huinker & Madison, 1997; Volkmann et. al., 2005). It could also be a result of a lack of observation of science or inquiry-based science in the field experience reported by some preservice teachers in this study.

It is also important to point out that this study was limited in that all the participants were whit females. Therefore this study could not examine the effect of gender, socioeconomic factors or ethnicity on preservice teachers understanding of inquiry-based pedagogy or confidence to teach science. It is not known how the results of this study would be impacted if ethnic, gender or socioeconomic mix of the participants was different. In a study conducted by Cantrell et. al. (2003), to examine the efficacy beliefs of a sample of preservice teachers at three stages of their education program, researchers found no gender effect on the PSTE beliefs between males and females after the methods course. Interestingly none of the males in this group reported participating in extra curricular science activities in high school, while only 17% of the females reported participating. Additionally, the percentage of males(57.1% in this group taking more than the required two years of science was similar to the percentage of females (63.6%).

Conclusion

Results of this study indicate that after concurrently completing the elementary science methods course and the science field experience both of which incorporate NSES recommendations for inquiry-based pedagogies for teaching science, the majority of the elementary preservice teachers report having an understanding about inquiry and inquiry-based pedagogy consistent with the NSES recommendations for science as inquiry for grades K-4, indicate confidence to teach science, are more accepting of inquiry-based pedagogies to teach science, report understanding the value of inquiry-based instruction to get students interested and confident in science, and report their intent to use inquiry-based pedagogy in their own classroom to teach science.

The findings indicate that when multiple inquiry-based experiences and inquiry-based instructional strategies are integrated into a traditional elementary science methods course and observed through the science field experience taken concurrently with the science methods course, preservice teachers overcome their apprehensions about teaching science through inquiry, understand the value of constructivist approach to inculcating interest and confidence in students to do science, are accepting of their role as facilitator of science learning, and start conceptualizing and defining their own pedagogical strategies which are consistent with the science education reforms articulated in the NSES.

Implications

The findings from this study have implications for the design of the elementary science methods course and the science field experience. Specifically, the findings of this research study suggest that when multiple inquiry-based experiences, spanning from guided to open inquiries, that challenge preservice teachers' learning in a constructivist environment are integrated into the elementary science methods course, preservice teachers not only develop an understanding of inquiry-based science instruction, but also develop an appreciation for the benefits of teaching and learning science in a constructivist environment, develop confidence to teach science and indicate comfort with using inquiry-based science teaching strategies in their own classroom practice when they become practicing teachers. Additionally, having preservice teachers concurrently involved in field experiences which reinforce inquiry-based science pedagogy taught in the elementary science methods course helps preservice teachers conceptualize their own pedagogy in science and helps them start defining and accepting their changing role as a facilitator as outlined in the NSES.

The preservice teachers in this study indicated positive self-efficacy and motivation to teach science based on successful modeling of teaching strategies in the methods course and the field and mastery experiences gained during the preparation and teaching of their inquiry-based science lesson plans to their peers in the science methods class. This is consistent with Bandura's contention that 'perceived self-efficacy' contributes significantly to the level of motivation and performance accomplishments.

However, the preservice teachers in this study did not do teaching of inquiry-based lessons to gain mastery of experience as defined by Bandura (1981) either in the field or in the science methods class. According to the study by Cantrell et al. (2003), preservice teachers in their study had the highest gain in PSTE through sustained teaching in the field for more than 3 hours across the span of their 3-week practicum in the field. Therefore, it is possible that their first experience of teaching science in their own practice might be negative. According to Bandura (1981), this could result in negative self-efficacy for teaching science for these preservice teachers.

In addition, the fact that literature points out that the NSES recommendations have not been implemented in a number of elementary schools (Weiss, et.al. 2003), it is conceivable that these preservice teachers might not get support from the school administration and their fellow teachers to implement inquiry-based science in their classrooms which too could affect their self-efficacy to teach science in a negative way.

Study Limitations

This research study was limited in that it examined the perceptions of elementary preservice teachers regarding their understanding of scientific inquiry and inquiry-based science pedagogy after concurrently completing a traditional elementary science methods course and its science field experience at only one campus. Also, due to the delays in the IRB approval, confidence evaluation through the STEBI-B instrument not be done at the beginning of the study, instead was done towards the end of the semester. This provided an assessment of the preservice teachers' confidence after successful completion of the science methods course and its associated science field experience which is valuable information in itself but not the difference in the confidence at the beginning and end of the study. Another limitation was that the use of focus groups rather than interviews with individual preservice teachers prevented the researcher from exploring the depth of understanding of preservice teachers regarding the various constructs which were examined through this study. This study was also limited in that all of the participants were white females from upper middle class. Therefore, this study does not represent effects of gender, ethnicity or socioeconomic factors on the preservice teachers' understanding of inquiry and inquiry-based pedagogy and hence their confidence to teach science.

Future Research Ideas

Not all campuses offer the elementary science education methods course and the science field experience in the same semester. Therefore, to draw generalizations of the effectiveness of the traditional elementary science methods course in teaching inquiry and inquiry-based pedagogy for teaching science, this research study needs to be extended to campuses concurrently offering the elementary science methods course and the science field experience and to those that do not offer the science field experience concurrently with the elementary science methods course. Additionally, follow-up research should be conducted with the elementary preservice teachers in this study to evaluate how many of them are actually using inquiry-based science pedagogies for teaching science in their classrooms.

Appendix A

Focus Group Protocol -Preservice Teachers

1. What in your opinion constitutes a scientific investigation?

2. Describe some investigations that you or the professor / instructor conducted in the elementary science education methods course?

3. Describe **unique** aspects of teaching strategies you observed during your field experience or in the elementary science education methods that will help you develop your own teaching strategies.

4. In your opinion how does the inquiry-based instruction facilitate learning of science?

5. How has the elementary science education methods course helped you understand the inquiry form of science instruction and the way science should be taught?

6. How did your elementary science education methods course increase or decrease your confidence to teach science at the elementary level?

7. How are the strategies taught in the elementary science education methods course consistent with your view of inquiry?

8. Do you plan to use inquiry to teach science?

Appendix B

Interview Protocol – Methods Instructors

1. What science teaching strategies did you teach/demonstrate to the preservice teachers?
2. In your opinion what are the basic elements of inquiry-based instructional strategies?
3. How was the inquiry form of instruction demonstrated to the preservice teachers during in the methods' course?
4. How do the teaching strategies emphasized in the methods course relate to the National Science Standard for teaching science?
5. How does the methods course help preservice teachers learn scientific investigational techniques?
6. In what way are the teaching strategies taught in the methods course effective to teach inquiry skills?
7. How does the elementary science education methods course help preservice teachers learn to analyze instructional materials for inquiry as content?
8. How does the methods course help preservice teachers develop confidence to teach science?

Appendix C

STEBI FORM B

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA = Strongly Agree
A = Agree
UN = Uncertain
D = Disagree
SD = Strongly Disagree

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2. I will continually find better ways to teach science.	SA A UN D SD
3. Even if I try very hard, I will not teach science as well as I will most subjects.	SA A UN D SD
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA A UN D SD
5. I know the steps necessary to teach science concepts effectively.	SA A UN D SD
6. I will not be very effective in monitoring science experiments.	SA A UN D SD
7. If students are underachieving in science, it is most likely due to ineffective science teaching.	SA A UN D SD
8. I will generally teach science ineffectively.	SA A UN D SD
9. The inadequacy of a student's science background can be overcome by good teaching.	SA A UN D SD

10. The low science achievement of some students cannot generally be blamed on their teachers.	SA A UN D SD
11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD
12. I understand science concepts well enough to be effective in teaching elementary science.	SA A UN D SD
13. Increased effort in science teaching produces little change in some students' science achievement.	SA A UN D SD
14. The teacher is generally responsible for the achievement of students in science.	SA A UN D SD
15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	SA A UN D SD
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	SA A UN D SD
17. I will find it difficult to explain to students why science experiments work.	SA A UN D SD
18. I will typically be able to answer students' science questions.	SA A UN D SD
19. I wonder if I will have the necessary skills to teach science.	SA A UN D SD
20. Given a choice, I will not invite the principal to evaluate my science teaching.	SA A UN D SD

21. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better. SA A UN D SD

22. When teaching science, I will usually welcome student questions. SA A UN D SD

23. I do not know what to do to turn students on to science. SA A UN D SD

Appendix D

Study Specific Questionnaire

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters below each statement.

SA = Strongly Agree
A = Agree
UN = Uncertain
D = Disagree
SD = Strongly Disagree

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1. Scientific investigations involve exploring questions generated by curiosity.
   SA A UN D SD

2. Describing objects/ events and constructing explanations all constitute scientific inquiry.
   SA A UN D SD

3. Testing explanations of phenomenon and communicating findings to peers is **not** part of scientific investigation.
   SA A UN D SD

4. Scientific learning is usually a result of collaborative effort between students.
   SA A UN D SD

5. Findings and data of scientific investigations do not need to be recorded.
   SA A UN D SD

6. Allowing students to explore science concepts on their own does **not** result in learning
   SA A UN D SD

7. As a science teacher I should support student curiosity by giving students time to explore explanations of scientific phenomenon.

SA A UN D SD

8. Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
SA A UN D SD

9. Different kinds of questions can be answered by different kinds of scientific investigations.
SA A UN D SD

10. I feel more confident to teach science after taking the elementary science education methods course.
SA A UN D SD

11. Overall the teaching strategies I observed in the science field experience are consistent with those taught in the elementary science education methods course.
SA A UN D SD

12. The teaching strategies I observed in the field were very different than those taught in the elementary science education methods course.
SA A UN D SD

13. Science teaching strategies used by cooperating teachers in my field experience to teach elementary science encouraged students to explore, observe, and challenge each other's findings.
SA A UN D SD

14. The elementary science education methods course along with the science field experience has given me the confidence to teach science
SA A UN D SD

15. I feel more confident about teaching science after having gone through the elementary science education methods course and the science field experience.
SA A UN D SD

16. Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models and theories.

SA A UN D SD

17. Current scientific knowledge and understanding do **not** guide scientific investigations.
    SA A UN D SD

18. Researching information in reference journals, on the internet, and the library all constitute scientific inquiry.
    SA A UN D SD

19. Communicating, sharing and reviewing each other's results are all a part of scientific inquiry.
    SA A UN D SD

20. The National Science Education Standards require students in K-5 to be able to ask questions, plan and conduct simple investigations, employ simple equipment and tools to gather data, use data to construct reasonable explanations and communicate investigations and explanations.
    SA A UN D SD

Appendix E

UNIVERSITY OF MISSOURI-COLUMBIA
RECRUITMENT Email
Preservice Teachers

You are invited to participate in a research study that examines the preservice elementary teachers' perceptions regarding confidence to teach science and the understanding of the inquiry form of pedagogical strategies for teaching science after going through the elementary science education methods course and science field experience.

Results of this study will be used to evaluate whether the elementary science education methods course along with the science field experience is effective in helping preservice teachers understand the inquiry form of science instructional strategies and whether it positively impacts the preservice teachers' confidence to teach science at the elementary grades.

I am interested in capturing your reflections regarding science teaching strategies taught in the elementary science education methods course and observed by you during your science field experience. This will be done through two surveys and through focus group discussions with some of you. The focus group discussions will last approximately 30-45 minutes and will be scheduled at your convenience.

All data gathered will be confidential and pseudonyms will be used in all write-ups of the research to protect the anonymity of the participants.

I require your written consent to participate in the study, which you can give by replying to this email. Attached you will find a detailed consent form that outlines the conditions of participation in the research. If you have any questions, please do not hesitate to contact me.

Sincerely,
Tina Varma

Appendix F

UNIVERSITY OF MISSOURI-COLUMBIA
INFORMED CONSENT
Students

Preservice Elementary Teachers' Perceptions of Their Understanding of Scientific Inquiry-Based Pedagogy and Their Confidence to Teach Science: Influence of Elementary science education methods Course and Science Field Experience

You are invited to participate in a research study that examines the preservice elementary teachers' perceptions regarding confidence to teach science and the understanding of the inquiry form of pedagogical strategies for teaching science after going through elementary science education methods course and science field experience.

Results of this study will be used to evaluate whether the elementary science education methods course along with the science field experience is effective in helping preservice teachers understand the inquiry form of science instructional strategies and whether it positively impacts the preservice teachers' confidence to teach science at the elementary grades.

INFORMATION

Your participation in this study is voluntary; you may choose not to participate and there will be no penalty or consequence to your grade. If you decide to participate, you may withdraw from the study at any time without penalty. Your course grade in TDP 4284 will not be affected by your decision to participate or to decline participation in the study. Only Tina Varma, the graduate student conducting this study, will know the identity of the individuals who choose to participate in the study.

PARTICIPATION

If you consent to participate in the study, you are agreeing to do the following towards the end of the semester (1) fill out the STEBI-B survey designed to evaluate preservice teachers confidence to teach science, (2) fill out a study specific survey to evaluate your understanding of scientific inquiry as a result of going through the elementary science education methods course and the science field experience, and (3) agreeing to participate in a focus group to reflect on your understanding of scientific inquiry and your confidence to teach science as a result of going through the elementary science education methods course and the science field experience.

Your responses on the surveys and the focus groups will be confidential. In reporting the research findings, your name will not be used but will be replaced with a pseudonym.

The focus group will be convened towards the end of the semester at a mutually agreed upon date/location, and will take approximately 30-45 minutes. Discussions in the focus groups will be audio taped and transcribed for analysis.
In compliance with Federal regulations, all data (including audiotapes) will be kept for a period of three years following the conclusion of the study. After that time, your data (including audiotapes) will be destroyed.

BENEFITS
Your participation in this research study will help teacher educators to evaluate whether the elementary science education methods course along with the science field experience is effective in helping preservice teachers understand the inquiry form of science instructional strategies and improve their confidence to teach science

The information gained in this study may be published and be useful to science teacher educators at other universities and colleges.

CONFIDENTIALITY
Your identity will be kept strictly confidential. During the semester in which you are enrolled in TDP 4284, the instructor will not know if you are participating in the study. Tina Varma will be the only person who knows if you have chosen to participate in the study. She will be convening and facilitating the focus group discussions and will be administering the surveys. In all transcriptions of the data, Tina Varma will remove your name and replace it with a pseudonym. Similarly, in reporting the findings of this study, your name will be replaced with this pseudonym. You may choose to end your participation at any time during the study, and your data will be destroyed.

RISKS

This project does not involve any risks greater than those encountered in everyday life. To ensure that your decision to participate or decline participation in the study does not affect your course grade, the course instructor will not have access to the data or begin the data analysis process until after course grades have been assigned.

This project has been reviewed by the University of Missouri-Columbia Human Subject Review Board. For additional information regarding human subject participation in this research, please contact the University of Missouri-Columbia IRB office at (573) 882-9585.

CONSENT

I have read and understand the above information, and I have received a copy of this form. By replying to the email I received, I indicate my willingness to participate in the study.

CONTACT INFORMATION

Tina Varma
Email: tv967@mizzou.edu
Dr. Judy Wedman (Advisor)
Email: judy@missouri.edu

Appendix G

UNIVERSITY OF MISSOURI-COLUMBIA
INFORMED CONSENT
Methods Instructors

Preservice Elementary Teachers' Perceptions of Their Understanding of Scientific Inquiry-Based Pedagogy and Their Confidence to Teach Science: Influence of Elementary science education methods Course and Science Field Experience

You are invited to participate in a research study that examines the preservice elementary teachers' perceptions regarding confidence to teach science and the understanding of the inquiry form of pedagogical strategies for teaching science after going through elementary science education methods course and science field experience.

Results of this study will be used to evaluate whether the elementary science education methods course along with the science field experience is effective in helping preservice teachers understand the inquiry form of science instructional strategies and whether it positively impacts the preservice teachers' confidence to teach science at the elementary grades.

INFORMATION
Your participation in this study is voluntary; you may choose not to participate.

PARTICIPATION
If you consent to participate in the study, you are agreeing to do the following: (1) provide a course syllabus for the elementary science education methods course TDP 4284 that you are teaching in the winter semester 2006 so that the researcher can assess how the National Science Education Standards requirements for inquiry are integrated into the course, and (2) allow the researcher to interview you for 30-45 minutes towards the end of the semester to capture your perspective on what teaching strategies are emphasized in the elementary science education methods course.

Your responses on the interview will be confidential.

The interview will be semi structured, will be conducted on the MU campus towards the end of the semester at a mutually agreed upon date/location, and will take approximately 30-45 minutes. The interview will be audio taped and transcribed for analysis.

BENEFITS

Your participation in this research study will help teacher educators to evaluate whether the elementary science education methods course along with the science field experience is effective in helping preservice teachers understand the inquiry form of science instructional strategies and improve their confidence to teach science

The information gained in this study may be published and be useful to science teacher educators at other universities and colleges.

CONFIDENTIALITY

Your identity will be kept strictly confidential. In compliance with Federal regulations, all data (including audiotapes) will be kept for a period of three years following the conclusion of the study. After that time, your data (including audiotapes) will be destroyed.

RISKS

This project does not involve any risks greater than those encountered in everyday life.

This project has been reviewed by the University of Missouri-Columbia Human Subject Review Board. For additional information regarding human subject participation in this research, please contact the University of Missouri-Columbia IRB office at (573) 882-9585.

CONSENT

I have read and understand the above information, and I have received a copy of this form. By replying to the email I received, I indicate my willingness to participate in the study.

CONTACT INFORMATION

Tina Varma
Email: tv967@mizzou.edu

Dr. Judy Wedman (Advisor)
Email: judy@missouri.edu

Appendix H

Elementary Science Education Methods Course Syllabus
Winter 2006
University of Missouri-Columbia

ED 4280-Teaching Science in the Elementary School

WS2006

Textbooks:

National Research Council (1996). National science education standards. Washington, D.C.: Author.

Peters, J. & Gega, P. (2002). How to teach elementary school science. Fourth edition. New York: Macmillan Publishing Company.

Evertson, C. Emmer, E & Worsham, M. (2005). Classroom management for elementary teachers' (6th ed.). Boston: Allun and Bucon.

Campbell, B. & Fulton, L. (2003). Science notebooks writing about inquiry. Portsmounth, N.H. : Heinemann.

Class Packet

Composition Notebook

The purpose of this lab-based course is to allow you to explore and provide evidence for supporting the idea that you can "do" science successfully so you will be able to teach elementary science effectively. This research-based course will emphasize science as a way of thinking and a discovery-oriented science curriculum. Based on the tenet of teaching as a decision making process, the core of this course will be formed by the roles and responsibilities of effective teachers of K-6 science, the promotion of problem-solving and creative thinking skills, teaching science across the curriculum, and dynamic lesson planning. The intent will be to offer prospective teachers the instructional designs and delivery systems that enhance the teaching and learning of elementary science. To facilitate your preparation for student teaching, in depth guided observations of elementary science specialists' will be required.

Your instructor will be modeling an inquiry teaching approach by continually employing extended wait-time and many times will not give immediate positive reinforcement. These techniques are used to encourage your thinking rather than to encourage frustration. Many of the teaching models studied in this course will be modeled through instruction.

You may earn 10 points extra credit by assisting with the State Science Olympiad competition on campus April 22, 2006.

MAJOR GOALS OF THE COURSE:

1. The student will utilize the National Science Education Standards (NSES) and/or Missouri GLE's to plan elementary science curriculum units of study. Curriculum, Assessment
1. The student will develop/refine personal skills in the use of inquiry in the teaching of elementary science. Curriculum, Assessment
1. The student will write/adapt lesson plans from exemplary science curriculum (FOSS, Insight, STC, AIMS, &/or GEMS) in designing science experiences that matches Showme Frameworks. Content, Instruction

- The student will expand his/her experiences focusing upon measurement and potential for integration with mathematics. Learners, Curriculum, Assessment
- The student will develop a broad orientation toward NSES science content (inquiry, physical, life, earth, personal & social, history & nature of science, science & technology). Instruction, Reflection
- The student will actively participate in long term projects (seeds) and short term learning experiences (magnets, electricity) as models to implement NSES. Content
- The student will actively participate in a field experience in a K-6 science classroom and analyze the learning opportunities for all K-6 students. Student Diversity, Classroom and Behavior Management, Professionalism
- The students will design/refine their portfolio with elementary science artifacts. Instruction
- The students will analyze their own professional development from a content, pedagogy, and content-pedagogy perspective as it relates to K-6 science.
- The student will use NSES and MAP guidelines to plan how they will assess student's science understanding. Curriculum, Assessment
- The student will utilize technology as a resource for the development of elementary science curriculum &/or instruction. Communication, Reflection

SPECIAL NOTES

1. If you have special needs as addressed by the Americans with Disabilities Act and need course materials in alternative formats, notify your course instructor immediately. Reasonable efforts will be made to accommodate your special needs.

2. Academic dishonesty is an offense against the University. A student who has committed an act of academic dishonesty has failed to meet a basic requirement of satisfactory academic performance. Thus, academic dishonesty is not only a basis for disciplinary action, but is also relevant to the evaluation of the student's level of performance.

3. All daily work that is turned in late for evaluation will be reduced by 1/4 of the total possible for each class meeting. This policy may be waived in extenuating circumstances. If you find that you are going to absent due to a commitment, I would appreciate being informed.

GRADING REQUIREMENTS

Letter Grade	Description
A Level	represents superior ability or attainment significantly beyond all minimum (average and required) expectations (criteria) (for numerical purposes, 97-100% A+, 93-96.9% A, 90-92.9% A-);
B Level	represents good ability or attainment which meets and exceeds many minimum expectations (87-89.9% B+, 83-86.9% B, 80-82% B-);
C Level	represents ability or attainment which is acceptable and meets all minimum (required) expectations (77-79.9% C+, 73-76.9% C, 70-72.9% C-);
D Level	represents ability or attainment which does not meet all minimum (required) expectations (67-69.9% D+, 63-66.9% D, 60-62.9% D-);
F	represents attainment of some but not a number of important minimum expectations and is, thus, not

appropriate for a minimum professional level of performance (0-59.9%)

Tentative Sequence of topics			Assignment
Week 1			
	Discussion:	What science is appropriate for elementary school?	Science Notebooking
		What are National Science Education Standards (NSES)?	
	Lab:	Glob	Journals
		Inquiry & Science Processes	Seeds started
Week 2 & 3			
	Discussion:	Underpinnings	Pendulums
	Lab:	Underpinning activities	
		Field experiences	
Week 4			
	Discussion:	Nature of Science	Raisin tonic
	Lab:	Managing Hands-on learning	
		Constructivist orientation to science	
Week 5			
	Discussion:	Test #1	
	Lab:	Planning for instruction	Magnets
		Connecting teaching and assessment	
		Technology	Food car
Week 6 & 7			
	Discussion:	Questioning strategies	
	Lab:	Different forms of the learning cycle	Seed notebook due
		Management issues	
Week 8			
	Discussion:	Planning for student's alternative	

		conceptions	
	Lab:	Concept mapping	Fast Plans started
Week 9			
	Discussion:	Parent interactions & Evening Science	Electricity
	Lab:	Special needs in science	
Week 10			
	Discussion:	Test #2	
	Lab:	Assessment	
Week 11			
	Discussion:	Cooperative learning	
	Lab:	Unit based standards	
		Curriculum Project	
Week 12			
	Discussion:	Science/Technology/Society	
	Lab:	Curriculum Project	
Week 13			
	Discussion:	Gender bias	
		Trade books	
	Lab:	Curriculum project	
Week 14			
	Discussion:	TBA	Fast Plants report due
	Lab:	Portfolio critique	Field experience

reflection due

ED 327 Calendar

Grade Sheet

Activities	Date Due	Possible Points	My Points
Scienceography	8/25	—	—
Concept inventory	8/25	—	—
Glob	—	5	—
Operational definitions	—	5	—
Pond	—	5	—
Pendulums	—	10	—
Raisin Tonic	—	5	—
Test #1	—	20	—
Magnets	—	10	—
Food car	—	5	—
Seeds	—	30	
Electricity	—	10	—
Operational questions	—	10	—
Concept map	—	5	—
Test #2	—	25	—
Wisconsin Fast Plants	—	10	—
Journals	—	10	—
Field experience weekly logs	—	30	—
Curriculum report (team)	—	20	—
Adaptations of lessons	—	20	—
Portfolio	—	20	—
Final	—	20	—
Totals	—	280	—

Appendix I

Science Field Experience Course Syllabus-Winter 2006
University of Missouri-Columbia

TDP 4284-Elementary Science Field Experience
WS2006

Preservice elementary students are placed in elementary school with a mentor teacher [science specialist (grades 4 and 5) or with a K-3 master teacher] to observe applications of teaching science. Your placement will be for two hours per week for at least 12 weeks providing 24 hours of field experience. Placements are scheduled by the Office of Field Experience with guidance of science education faculty and Sara Torres, science coordinator for Columbia Public Schools.

Course Objectives

1. Students will apply knowledge learned from prior and current education courses as they observe and participate in field placement classrooms. [NCATE 1 & 2 (Instructional Strategies), Mo-STEP 1.2.1]
2. Students will collaborate with the mentor teacher to identify instructional activities, materials, and evaluations. [NCATE 2 (Communication), Mo-STEP 1.2.7, 1.2.9, & 1.2.10]
3. Students will reflect on each school visitation to compare and contrast what they are learning to what they are experiencing. [NCATE 4 (Reflection), Mo-STEP 1.2.7]
4. Students will investigate professional practices and professional organizations that are associated with the mentor teacher's practice. [NCATE 10 (Professionalism), Mo-STEP 1.2.10]

Attendance

You are expected to attend the field experience as established by the Office of Field Experience. However, preplanned adjustments in your schedule may be made with approval. In the event of an emergency, please notify your mentor teacher prior to your absence. You are required to record your attendance on a card provided by your instructor, as well as sign in at your school's office. Your cooperating mentor teacher should initial your card. Please turn in your card to your instructor at the end of the field experience. You must arrange a time with your mentor teacher to make up any missed time and assignments.

On each visit you are to stop in the Principal's office to sign in. Introduce yourself and report that you are there to observe the teaching of science. Columbia Public Schools expect your attire to be professional.

Weekly Logs

During the field experience you will be observing both the teacher and students. Each weekly submission should include date, site, context of instruction(s) observed, skills (both number and description) listed below, and connected reflection(s) about what you think as well as observed happened. Each connected reflection is to be connected to previous courses, experiences, readings, and/or discussions. Your reflection could also address what went well, surprises, what you learned. Use pseudonyms in reference to all field experience contacts. This log is to be submitted prior to Monday (6:00 AM) either electronically or hard copy (typed or hand written). Each submission has a mastery level so resubmissions are to include changes in capitals. Each resubmission is to be completed within two weeks to meet the course requirement.

Final Submission

One week after your last field experience visit, a typed summary of your field experience is due. This summary should summarize your personal growth regarding the teaching of science in relation to NSES teaching standards. Provide specific evidence that documents your growth, but do not restate what you wrote in weekly logs.

Professionalism

1. Be on time, dressed appropriately, and adhere to conduct in a professional manner.
2. Be prepared each day to assist mentor teacher.
3. Call in absence well in advance.
4. Communicate with your mentor teacher on a regular basis.
5. Return materials borrowed from the mentor teacher.
6. Write a thank you note to your mentor teacher.

Grading

Each student will receive a passing grade if they:

2. Attend the field experience on a regularly scheduled basis for a total of 24 hours.
3. Submit one journal response for each visit. Failure to submit weekly will result in fewer points in TDP4280.
4. Submit a final summary of the field experience.

During your visit, you are to observe how the mentor teacher addresses a variety of situations. During your visits you will complete all tasks from LIST A and more than four tasks from LIST B to document. Be sure to identify by list A or B, number, and title which item you are reporting. Please inform your mentor teacher which task you want to focus upon that day. You should take notes during the class and write your weekly journal outside of class.

LIST A

2. Write a record of questions asked, student responses and teacher reaction for 10-15 minutes. After class, analyze the types of questions, student responses, etc. Write a brief summary based on your data.
3. Focus upon one child for 10 minutes and write anecdotal notes for what the child does every 20 seconds. Write a brief summary based on your data.
4. Focus upon one group for 10 minutes and write anecdotal notes for what the group members do every 20 seconds. Write a brief summary based on your data. (Must be a science class).
5. Describe how the science specialist modified lesson for meeting the needs of special needs students.
6. Participate in an after school enrichment program (Evening Science, Exploring Physics, or Family Math) and compare and contrast this experience with "typical" science/mathematics learning experiences.
7. Analyze the science content presented and how it was taught. How do the lesson's Big Ideas match with NSES/Missouri Frameworks.
8. For 15-20 minutes, track and record the location of the science specialist (teacher) in relation to student responses (submit map).
9. Assist with a group of students during an investigation.

LIST B

2. Compare teachers' questions utilized prior to and after a student activity.
3. List examples of behavioral expectations transmitted to students.
4. List examples of covert and overt teacher behaviors (with definitions) that promote positive classroom atmosphere.
5. Report strategies utilized to bring student/group of students back on task.
6. Describe strategies utilized to involve all students in discussion and/or hands-on activities.

7. How does the science specialist deal with “problem children?”
8. What motivational strategies were effective?
9. How did the science specialist ascertain whether content (learning) objectives were accomplished?
10. How were task groups utilized? Summarize intra-group behavior, material distribution and retrieval.
11. Analyze procedural directions for clarity, sequence, and overall effectiveness.
12. Describe how the science specialist assesses student performance (individual and group)
13. Describe how students and/or teachers utilized technology aspects of *NSES* or instructional technology.
14. Compare and contrast how Science Notebooks are used in relation to TDP 4280.

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