AN EXAMINATION OF THE FACTORS RELATED TO ELEMENTARY SCHOOL CLASSROOM TEACHERS' SELF-EFFICACY AND THE IMPACT OF SELF-EFFICACY BELIEFS ON TEACHING OUTCOMES IN SCIENCE

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AN EXAMINATION OF THE FACTORS RELATED TO ELEMENTARY SCHOOL
CLASSROOM TEACHERS' SELF-EFFICACY AND THE IMPACT OF SELF-EFFICACY
BELIEFS ON TEACHING OUTCOMES IN SCIENCE

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MPA, Pace University, 1982
BA, Pace University, 1976

A Dissertation
Submitted in Partial Fulfillment of the
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Doctor of Education in Instructional Leadership
in the
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at
Western Connecticut State University
2012
AN EXAMINATION OF THE FACTORS RELATED TO ELEMENTARY SCHOOL CLASSROOM TEACHERS’ SELF-EFFICACY AND THE IMPACT OF SELF-EFFICACY BELIEFS ON TEACHING OUTCOMES IN SCIENCE

Deborah Ann Mumford, BA, MPA, EdD

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Abstract

This study examined kindergarten through fifth grade elementary school teachers’ self-efficacy regarding classroom science teaching and then related these findings to the daily instructional methods that these teachers use when teaching science. Survey methodology was used to explore the perceptions of elementary school teachers (n = 143) regarding science teaching, specifically relating these perceptions to a number of factors: gender, number of years of experience teaching science, grade level taught, number of elective undergraduate science courses, highest degree earned, and whether or not the participants had earned a science degree. In addition, participants’ self-efficacy was used to predict teachers’ frequency of questioning and thinking strategies in classroom science instruction.

Participants completed the Classroom Science Instruction Survey (CSIS) which included: (a) demographic items, (b) the Science Teaching Efficacy Belief Scale (STEBI-A); (c) the Classroom Practices Survey (CPS) that explored teachers’ frequency of questioning and thinking strategies, and (d) open-ended items that explored participants’ underlying perceptions regarding classroom science teaching. Response rate for survey completion was 79.2%.
Multiple regression results indicated that having taken three or more elective undergraduate science courses and teaching fifth grade science significantly predicted self-efficacy in science instruction. In addition, self-efficacy predicted the frequency of questioning and thinking skills used by teachers in the science elementary school classroom. Qualitative results indicated that teachers believed that specific curriculum and teacher-based strategies fostered student interest, and encouraged challenging content and higher-order student thinking skills, which resulted in increased frequency of student questioning. Teachers identified specific inquiry beliefs and practices and their relationship to developing self-efficacy, but noted specific barriers in the elementary school science classroom environment that hinder this process. Implications for educators and suggestions for future research are discussed.
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2012
APPROVAL PAGE

School of Professional Studies
Department of Education and Educational Psychology
Doctor of Education in Instructional Leadership

Doctor of Education Dissertation

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CLASSROOM TEACHERS’ SELF-EFFICACY AND THE IMPACT OF SELF-EFFICACY
BELIEFS ON TEACHING OUTCOMES IN SCIENCE

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My professional journey has been a winding road, with dedicated educators and scholars, motivating me to learn and search for more. I truly believe that science holds the answers to questions we have not yet learned to ask. I am most indebted to my dissertation committee members who have inspired and shaped my passions into this study. You have all challenged me to make my work authentic, relevant, and purposeful.

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to my own children throughout their high school years. I will always appreciate your willingness to be a part of my doctoral journey.

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My research could not have taken place if it were not for the district and building administrators who invited me into their schools and allowed me to conduct my study. I would also like to extend a special thank you to the elementary school classroom teachers in my study, who like myself, juggle the complexities of teaching math, science, language arts, and social studies, all in a single day. I appreciate your willingness to have been a part of this project and your honesty in sharing what was important to you. You have all made this work possible, and I am indebted to you.

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DEDICATION

This work is dedicated to my loving family for all their support while I went back to school...again. To my husband, Allan, the love of my life, I thank you from the deepest part of my soul for allowing me to grow and pursue my dreams and for always being proud of me. You made dinner, shopped and cleaned while I wrote and wrote; I share this honor with you. And to my children, Heather and her husband Joshua, Nathan and Wendy, and to my dearest brother John, who survived many a holiday or two with WCSU; I am so grateful that you agreed to this journey even though we really did not know what we were getting into. I hope I inspired you to value the search for learning as much as you can and to follow your dreams. Believe in yourself and always commit to excellence.

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So here I am, more than 35 years later, and the journey continues! I hope I can give to those looking for inspiration this love for teaching and discovery about the world that surrounds us. I am thankful. I am hopeful. I am blessed.
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CHAPTER ONE: INTRODUCTION TO THE STUDY

Science education is faced with the challenge of preparing a scientifically literate national work force that is equipped to compete in an increasingly scientifically and technologically oriented global economy (Lumpe, Haney, & Czerniak, 2000). To promote awareness of that goal, numerous policy reports have called for a national agenda for scientific literacy, focusing on reforms that will improve classroom science instruction (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). Improving science instruction, however, is a complex task, in that it involves revising curriculum, changing the way children are taught, and adapting new methods of assessment (Lumpe et al., 2000).

Part of the key to improvement may lie in the fact that elementary school teachers often lack belief in their ability to provide science instruction as well as they provide instruction in other areas of the elementary school curriculum (Metz, 2008). Bandura’s (1981) theory of self-efficacy is the belief held by the individual that he or she is able to do something to produce a specific outcome and "a person's estimate that a given behavior will lead to certain outcomes" (1977, p. 79). Researchers (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998) have suggested that an important characteristic of effective teaching is a teacher’s sense of self-efficacy, which may be correlated with positive teacher and student outcomes. There is some evidence (Hoy & Woolfolk, 1990) that self-efficacy beliefs may change during pre-service teaching experiences, however little is known about the self-efficacy of practicing teachers. This study examined both internal and external factors that are associated with practicing teachers’ self-efficacy.
The evaluation of teacher self-efficacy as an indicator of teacher classroom behavior has also been studied by many researchers in the field of science education (Brickhouse, 1994; Czerniak & Chiarelott, 1990; Czerniak & Shriver, 1994; Levitt, 2001; Lumpe, Czerniak, Haney, & Beltyukova, 2004; Lumpe et al., 2000; Moseley, Reinke, & Bookout, 2003; Ramey-Gassert, Shroyer, & Staver, 1996). However, little is known about whether greater self-efficacy translates into increased pedagogically sound teaching strategies that offer students more opportunities to practice questioning and thinking skills, another focus of the current research.

**Rationale for Selecting the Topic**

The Trends in International Mathematics and Science Study (TIMSS) provides reliable and timely data on the mathematics and science achievement of the U.S. and other international countries. Specifically, it affords educational researchers an opportunity to examine fourth and eighth grade students’ science scores and to make international comparisons of student science achievement. The U.S. science achievement scores on the 2007 TIMSS report offer clear evidence that a problem exists, as the U.S. ranks fifth out of 16 participating international countries (National Center for Educational Statistics, 2009).

Numerous disparate policies outlining science reform recommendations exist, yet a unifying direction is slowly emerging (AAAS, 1998; NRC, 1996). Recommendations have included teaching in a constructivist manner, taking into account students’ learning styles, incorporating cooperative learning and thematic approaches, training teachers on good classroom management and assessment and evaluation techniques, promoting equity, and teaching students to understand the nature of science and science content knowledge (Haney
Therefore, it would seem that the most practical change must begin with elementary school teachers and focus on their beliefs regarding professional practice.

Previous research related to pre-service teachers’ self-efficacy in science has focused on developing teacher beliefs to yield positive student learning outcomes (Plourde, 2002). These findings are consistent with Bandura’s (1977) research, which found that to be effective, one must believe that he or she can be task-effective. Before improving existing science classroom practices, researchers must understand factors related to practicing teachers’ self-efficacy in the science classroom, as they may be crucial in shaping instructional behavior (Plourde, 2002). Practicing teachers are on the front lines with students. If they are to be agents of change, their self-efficacy for teaching and student learning in science are truly at the core of educational reform.

Statement of the Problem

Early researchers (Cunningham & Blakenship, 1979; Hone, 1970; Mechling, Stedmen & Donnelley, 1982) found that teachers perform some instructional tasks more competently than others (Schoenberger & Russell, 1988). The complexities of teaching science demand a knowledge of content and processes used by scientists, and the skillful organization of materials and activities for student exploration (Jarrett, 1998). It is a complicated process.

Intricate relationships exist among the constructs of attitudes, beliefs and self-efficacy. For example, clusters of beliefs around a particular situation form attitudes, and attitudes become the action agendas that guide decisions and behavior (Duran, Ballone-Duran, Haney, & Beltyukova, 2009). Riggs and Enochs (1990) offered a theoretical explanation of these constructs: “An elementary school [science] teacher judges his/her ability to be lacking in science teaching (belief) and consequently develops a dislike for
science teaching (attitude). The result is a teacher who avoids teaching science if at all possible (behavior)” (p. 625).

If the role of science teachers is to facilitate beneficial student learning experiences, it is imperative that teachers develop and maintain a strong belief in their own capabilities to provide effective instruction. According to Smolleck, Zembal-Saul, and Yoder (2006), teachers who do not believe in their ability to teach science possess low self-efficacy and may avoid science instruction altogether. However, little is known about how practicing teachers develop and maintain self-efficacy in their ability to teach science. Therefore, this research examined the internal and external factors that influence the development or lack of development of this self-efficacy, as well as whether and how increased self-efficacy translates into inquiry-based practices in the classroom.

Since the mid-1990s, organizations promoting science education advancements have called for science instruction through inquiry (AAAS, 1993; NRC, 1996). Teaching science as inquiry shifts the goal of learning science from acquiring a collection of facts about natural phenomena to developing a deeper understanding of the natural world by connecting scientific ideas to evidence and reasoning. Inquiry-based instruction promotes the use of process skills for in-depth scientific concept exploration (Garcia, 2004), and inquiry-based science programs provide students opportunities to practice their reasoning skills with authentic problem solving (Garcia, 2004). Therefore, the study also focused on the relationship between elementary school teachers’ self-efficacy and inquiry-based practices that promote students’ questioning and thinking skills in science, and how self-efficacious teachers translate this quality into classroom practice.
Potential Benefits of the Research

Previous research (Supovitz & Turner, 2000) has demonstrated that teachers’ characteristics influence the outcomes of professional development, experience, and practice. This current research explored the relationships that exist between gender, grade level taught, years of classroom teaching experience, highest degree earned, number of elective undergraduate science courses, and whether or not participants had earned a science degree. The results of the study offer additional insight into the identified factors associated with practicing teachers’ (rather than pre-service teachers’) increased or decreased self-efficacy in science teaching. This information may allow districts to address the issue of how to develop self-efficacy in practicing science teachers in a more targeted manner. For example, districts might offer specific types of professional development opportunities in science (e.g., mentoring programs, peer teaching, and field experiences).

Understanding whether and how increased self-efficacy translates into inquiry questioning and thinking strategies is important for professional development committees and administrators at the district level. This understanding will allow district personnel to incorporate self-efficacy into professional development for inquiry-based practicing, contributing to the call for better inquiry-based science instruction. Improved professional development opportunities for teachers will aid in educational reform measures that feature more effective elementary school classroom science teaching, thereby enhancing and supporting student learning.

Definition of Key Terms

The following terms are defined for the purpose of this research study:

1. *External factors* are activities or events which a participant experiences that may or may not impact self-efficacy. For example, external factors may include the type of
degree earned, the highest degree earned, years of teaching experience, and grade level taught.

2. Higher order questions are open-ended questions or questions that encourage reasoning and logic.

3. Internal factors are factors with which individuals are born, such as gender, that they naturally acquire, such as age, or that they will develop as a result of the external environments they have experienced, such as attitude, but may or may not impact self-efficacy.

4. Inquiry, inspired by the teachings of John Dewey's four primary interests of the child (Dewey, 1902), refers to an active learning approach that engages students in the process of exploring the natural or material world, leading them to ask questions and make discoveries as they try to make sense of their surroundings (University of Illinois, 2010).

5. Questioning skills are an example of one critical thinking strategy that a teacher may utilize, offering students opportunities to apply, analyze, synthesize, or evaluate information so that they may achieve a deeper and broader involvement with content (Maker, 1982).

6. Self-efficacy is described by Bandura (1977) as a belief that a person could do something to produce a specific outcome and "a person's estimate that a given behavior will lead to certain outcomes" (p. 79). As with most motivational and attitudinal concepts, self-efficacy is considered to be context specific (Bandura, 1982; Pajares, 1996).

7. Teacher attitude refers to a “general positive or negative feeling toward something”
8. *Teacher beliefs* refer to an “individual’s judgment of the truth or falsity of a proposition” (Pajares, 1992, p. 316) or “information that a person accepts to be true” (Koballa & Crawley, 1985, p. 223).

**Methodology**

This research employed cross-sectional survey research to obtain data “from one point in time, but from groups of different ages, or at different stages of development” (Gall, Gall, & Borg, 2007, p. 305). This research utilized a convergent parallel mixed method approach to address the following research questions:

**Research Questions and Hypotheses**

1. To what extent and in what manner do the internal factor (gender) and external factors (grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, science degree-yes or no) predict self-efficacy in science teaching for practicing elementary school teachers who teach science in grades K-5?

2. To what extent and in what manner does self-efficacy predict the (self-reported) occurrence of higher order questions for practicing classroom teachers who teach science in grades K-5?

3. How do practicing elementary school teachers view the importance of questioning skills in science instruction?

4. What instructional methods do practicing teachers in grades K-5 prefer to use when they teach elementary school science? Why?
Hypotheses

1. The internal factor (gender) and external factors (grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, science degree-yes or no) will predict self-efficacy in science teaching for practicing elementary school teachers who teach science in grades K-5.

2. Self-efficacy will predict the (self-reported) occurrence of higher order questions for practicing classroom teachers who teach science in grades K-5.

Description of the Setting and the Subjects

The participants in this study (n = 143) consisted of a sample of convenience selected to suit the purpose of the study. The target population consisted of elementary school classroom teachers in grades kindergarten through fifth grade responsible for teaching classroom science curriculum. Six school districts in the northeast were involved in this study. In two of the six districts, participants were drawn from each of two elementary schools located in the district. One elementary school participated in each of the remaining districts.

The districts spanned two states and two counties that are in close proximity. Two of the districts were located in suburban cities and four of the districts were located in suburban towns. These districts were selected as possible research sites as they were representative of a wider socioeconomic population, demonstrated by the free and reduced lunch statistics reported for each district’s student populations (see chapter three).

The districts ranged in size from 1,351 students to 4,322 students in grades K-5. The number of possible science classroom teachers in the eight schools in which the study took place was 183. Most teachers taught science as part of their classroom day. However, the
researcher discovered after completing data analysis that fifth grade teachers at the schools were assigned to teach science specifically because of their talent and interest in the subject. More detailed information on teachers’ demographics is provided in chapter three.

**Instrumentation**

Data were collected through the administration of a survey, the Classroom Science Instruction Survey (CSIS) (Appendix A), which contained four sections: (a) a set of demographic items (Appendix B); (b) open-ended items (Appendix C); (c) the Science Teaching Efficacy Belief Instrument (STEBI-Form A) (Appendix D), the Personal Science Teaching Efficacy Beliefs subscale from the STEBI – A (Appendix E; Riggs & Enochs, 1990); and (d) the Classroom Practices Survey (CPS) from the National Research Center on the Gifted and Talented (NRC/GT) (Appendix F), Questioning and Thinking subscale of the CPS (Appendix G; Archambault et al., 1993). Permission to use and publish these instruments was obtained.

The STEBI-A was designed by Riggs (1988) and Riggs and Enochs (1990) to develop and partially validate a self-reported elementary teachers’ efficacy belief instrument based on Bandura’s (1981) self-efficacy research. The STEBI-A is considered to be a valid and reliable self-efficacy instrument widely used to measure science self-efficacy in in-service (practicing) teachers (Morrell & Carroll, 2003). The instrument consists of two scales: (a) Personal Science Teaching Efficacy Belief Scale (13 items for self-efficacy determination) and (b) the Science Teaching Outcome Expectancy Scale (10 items for outcome expectancy dimension). The complete STEBI –A survey is therefore composed of 23 Likert-type questions based on a scale of 1-5. In the current research, only the Personal Science Teaching Efficacy Beliefs subscale (Appendix E) was used.
The current research also examined whether elementary-school teachers’ science self-efficacy scores predict their frequency of high-level questioning methods in the classroom. The NRC/GT Classroom Practices Teacher Survey was originally designed to enable researchers to determine the extent to which gifted and talented students receive differentiated education in regular classrooms across the United States (Archambault et al., 1993). However, in the current study, which used only the Questioning and Thinking subscale (Appendix G), the instrument was administered to the participants without the gifted and average annotations. The Thinking and Questioning subscale consists of 5 items and utilizes a 6-point Likert-type scale; it demonstrated a high alpha reliability of .83 in previous research (Archambault et al., 1993), making it a reliable measure.

A teacher beliefs section contained five open-ended items to elicit authentic responses from individual teachers regarding their science teaching and to assist in the triangulation of quantitative data. These open-ended items asked participants to reflect on their past experiences influencing their classroom science instruction, to discuss what good elementary science teaching entails, and to describe the challenges they face in accomplishing the task. The research sample consisted of 143 elementary school classroom teachers in grade levels K-5 from eight sampled schools within six school districts in the northeast. Researchers responsible for the development of the STEBI-A and the NRC/GT Classroom Practices, Questioning and Thinking instruments provided written permission for the instruments to be used and published in this study (Appendix H).

The researcher read from a prepared script when she administered the survey herself at the research sites (Appendix I). An Informed Consent sheet (Appendix J) was attached to the front of the survey that was provided for the participants. This Informed Consent Sheet
(Appendix J) described the purpose of the research, discussed how the research was voluntary and confidential, and provided contact information for the researcher. This information and the study’s procedures had been approved by the WCSU Institutional Review Board (IRB). Once participants had signed the Informed Consent Sheet, indicating that they agreed to participate in the study, they completed the Classroom Science Instruction Survey (CSIS) during their regularly scheduled faculty meetings. All access to the various research sites were previously secured from the district superintendents and their representatives for their districts and from the building administrators at the individual elementary schools. Sample blank permission forms for superintendents and building administrators are located in Appendices L and M, respectively.

**Description of the Research Design**

The research design used for this study was a convergent parallel mixed method. According to Creswell and Plano-Clark (2011), quantitative and qualitative approaches are used together for the purpose of providing the researcher with a deeper understanding of the research problem. Research questions one and two were quantitative and correlational in nature. The correlational design is most appropriate to explore relationships among a large number of variables in a single study, or the degree of the relationship between the variables (Gall et al., 2007). This design supported the ability of the STEBI-A to predict questioning and thinking subscale scores on the CPS for research question two. A general qualitative research design was deemed most appropriate for research questions three and four to “discover…meaning and interpretations” (Gall et al., 2007, p. 650).
Description and Justification of the Analyses

Multiple linear regression was utilized to address research questions one and two. According to Meyers, Gamst, and Guarino (2006), multiple linear regression is useful when “using more than one predictor can paint a more complete picture of how the world works than is permitted by simple linear regression because constructs in the behavioral sciences are believed to be multiply determined” (p. 147). Predictor variables for research question one included gender, number of years of experience teaching science, highest degree earned, grade level taught, number of elective undergraduate science courses, and degree (science or non-science). These predictor variables were created as categorical variables, with the exception of number of years of experience teaching science, and so dichotomous coding was necessary before performing regression procedures. The criterion variable for research question one consisted of the mean subscale score on the STEBI-A. Predictor variables for research question two consisted of the mean subscale score on the STEBI-A and the criterion variable consisted of the mean subscale score on the Questioning and Thinking Subscale of the CPS.

Tabachnick and Fidell (1989) suggest that the necessary sample size for a multiple linear regression is $N = 50 + 8(m)$, in which $m$ is equal to the number of independent predictors. Although there were only six predictor variables (gender, grade level taught, years of experience teaching science, highest degree earned, number of elective undergraduate science courses taken, and science degree -yes or no), five of these predictor variables were categorical. Therefore, dichotomous coding was necessary for these predictor variables, resulting in 13 predictor variables. The necessary sample size to perform the multiple linear regressions for research questions one and two was approximately 154
participants. The final number of usable surveys \((n = 143)\) were not as high as suggested, but were sufficient for data analysis to occur.

Research questions three and four were addressed qualitatively using three levels of coding techniques—open coding, axial coding, and selective coding, which was applied to the data as suggested by Strauss and Corbin (1998). Data were first coded into open codes. These were then combined into broader categories in axial coding, allowing core categories to emerge during selective coding. The core categories were then verified using an interpretative analysis technique (Gall et al., 2007) to identify general themes that emerged.

**Data Collection Procedures and Timeline**

The research was conducted according to the following timeline:

1. Confirmed participation—The researcher confirmed district and school level participation in the study, initially by phone and then by written electronic correspondence. Eight districts agreed to participate, and three districts that were approached decided against participation due to time constraints (January - March 2011).

2. Conducted site visits—Site visits to the participating schools were conducted during teachers’ scheduled faculty meetings. After a brief introduction, an Informed Consent Sheet was distributed. Surveys were administered and collected and incentive rewards distributed at four of the eight sampled schools. These four schools requested an alternate plan which consisted of a district administrator, building principals and a teacher volunteer who provided surveys to teachers. Upon their return, these surveys were collected by the researcher within 2 days of their administration (March – May 2011).
3. Entered data; began writing dissertation—Data were collected using the CSIS instrument and entered into SPSS and EXCEL, then checked for accuracy. Dissertation chapters one and two were written (June 2011 – July 2011).

4. Performed data analysis; continued writing dissertation—Qualitative and quantitative assumptions were checked and data were analyzed. Dissertation chapter three was written (July 2011 – September 2011).

5. Reporting—Dissertation chapter four was written (October - November 2011).

6. Conclusion and Future Research – Dissertation chapter five was written (December 2011- January 2012).

**Ethics Statement**

Permission to participate in this research was obtained from the superintendent or directed administrator by the district’s superintendent, the deputy superintendent, each school principal, and each elementary school teacher. To ensure anonymity, no names were assigned to the collected data. Identifying school codes were placed on surveys for school identification purposes only. All data were collected by the researcher and entered into a password protected computer database. Results of the study were made available to those participating principals who requested it.

**Summary**

Elementary-school teachers are on the front lines, leading the charge of science reform. If teachers are expected to act as agents of change (Duschl, 1990) and increase the science achievements of younger students, self-efficacy must be understood within the domain of science instruction. Teachers who believe that they can teach science as easily as
they teach other subjects may utilize strategies that encourage elementary school students to develop more competent science understandings.

The current research addressed gaps in the literature regarding the self-efficacy that practicing elementary school science teachers have regarding their professional practice by exploring: (a) the internal and external factors that may be associated with practicing teachers’ self-efficacy in science instruction; (b) the relationship between self-efficacy and the teaching of thinking and questioning skills in the classroom; and (c) the types of instructional methods practicing teachers find useful when they are teaching science.
CHAPTER TWO: REVIEW OF THE LITERATURE

To create a context for this study, the review of literature is divided into two parts: the theoretical rationale for the study and the factors related to self-efficacy that influence kindergarten through fifth grade elementary school classroom science instruction. The theoretical rationale explores constructs that relate to teacher performance and pedagogy for improved science instruction: effective inquiry-based classroom practices including questioning techniques that promote science education, and the beliefs, values and goals that influence teacher behavior. The second section presents the factors related to science self-efficacy: gender, number of elective undergraduate science courses, number of years teaching classroom science, grade level taught, science degree, and highest degree earned.

Theoretical Rationale

The Need for Improved Science Instruction

The National Science Resource Center of the Smithsonian (2011) has noted that efforts to improve science education date back as far as the early decades of the last century, initiated by reformists such as John Dewey, James Conant, and Vannevar Bush. The movement gained momentum with the launch of Sputnik in 1957, which sparked a revitalization of science education by policymakers, scientists, curriculum developers, and educational researchers. Of particular concern was elementary school students’ inability to “inquire scientifically and to understand and apply scientific knowledge” (Dana, Campbell, & Lunetta, 1997, p. 420). At that time, the newly-created National Science Foundation (NSF) developed innovative curricular materials that promoted an inquiry approach, suggesting that teacher and student knowledge as well as an understanding of the world can occur when science is more experiential in nature.
In the 1980s, the reform movement was ignited with the release of *A Nation at Risk*, developed by members of the National Commission on Excellence in Education, and the subsequent rise of the new standards movement. A steady decline in the science achievement scores of U.S. secondary students was reported by national science assessments in 1969, 1973, and 1977 (National Commission on Excellence in Education, 1983). The sobering numbers served as a call to arms for science education in the nation’s secondary schools, with the committee’s recommendation that graduates be offered an introduction to: (a) the concepts, laws, and processes of the physical and biological sciences; (b) the methods of scientific inquiry and reasoning; (c) the application of scientific knowledge to everyday life; and (d) the social and environmental implications of scientific and technological development (National Commission on Excellence in Education, 1983). It was also suggested that science courses be revised and updated for both the college-bound and those not intending to go to college.

**Sample size**

These efforts resulted in the development of the National Science Education Standards, which placed a new emphasis on guiding students in active and extended scientific inquiry (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). However, despite suggested reforms, organizations such as the AAAS and the NRC noted the continued lack of science literacy for elementary school students. Educational researchers’ Wallace and Louden (1992) wondered:

Why, after more than three decades on the reform agenda, does elementary science teaching continue to disappoint? Is it because we haven’t found the right “formula,”
or could it be that we have an imperfect understanding of the problem and unrealistic expectations for the solution? (p. 508)

Current researchers such as Metz (2011) have continued to describe how the “reform of elementary school science is a fundamental part of the solution” (p. 68).

The U.S. is not alone in this crisis. Results are also disappointing for science education reforms in Australia, Canada, New Zealand, and the United Kingdom which also promote science literacy as an ability enabling students to construct understandings of the big ideas in science. In fact, the 2006 Program for International Student Assessment (PISA) reported that, out of 30 developed nations, the U.S. ranked 21st on the assessment (Banko et al., 2010).

The Trends in International Mathematics and Science Study (2007, TIMSS), is published by the National Center for Educational Statistics (2009). In this assessment, students in grade four (and the equivalent) from 16 countries in the international community are compared. The U.S. participated in both the first TIMSS in 1995 and the most recent TIMSS in 2007, and therefore the average science scores can be compared over a 12-year period. In 2007, the average score for U.S. fourth graders (539) ranked fifth, compared to Singapore (587) which ranked first. From 1995 to 2007, scores for U.S. fourth grade students dropped by 3 points, although the difference was not significant. The goal of quality science education is to enable students to apply the big ideas in science learning to realistic problems and issues involving science, technology, society, and the environment (AAAS, 1993). Researchers (Hand, Prain, & Yore, 2001) have defined science literacy as the important role an educated populace plays in informing and persuading other people to take action based on valid science content and processes. Norris and Phillips (2003) described
these aspects of science literacy as both fundamental (literate practice in science) and derived (understanding the body of science content).

The North American science reform documents have identified a series of grade-level abilities, critical responses, processes, and emotional dispositions that are: (a) reflected in the nature of science; (b) involved in scientific inquiry; and (c) required for students to construct their own scientific understandings of this science literacy (AAAS, 1993; NRC, 1996). Research findings focused on science literacy (AAAS, 1993; Duschl, 1990; NRC, 1996, 2000; Riggs & Enochs, 1990) have indicated that our overall approach to the teaching of science is failing our students, and that realistic science reform should be a top priority.

Researchers (Metz, 2008, 2011; Spooner & Simpson, 1979; Stevens & Wenner, 1996) have suggested that early exposure to science and mathematics learning in elementary school leads to later cognitive skill development. The National Science Board Commission on Pre-college Education in Mathematics, Science and Technology noted that, within the formative years, “substantial exposure to mathematical and scientific concepts and processes” is “critical to later achievements” (National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1983, p. 22). Early science instruction (Yoon & Onchwari, 2006), engages young children in activities that encourage the development of scientific concepts and processes. According to these researchers, it offers them opportunities to develop important developmental science skills such as learning to: (a) think; (b) question; (c) make observations; (d) classify objects; (e) communicate and interact with others (f) measure; (g) make predictions and inferences; (h) carry out experiments; and (i) build models (Yoon & Onchwari, 2006).
The rhetoric of reform has challenged national organizations to band together to present reforms that center on national science standards, teacher training and support, better allocation of resources and program delivery (NRC, 2000). For example, the AAAS developed and implemented Project 2061, a long-term initiative with the goal of promoting students’ literacy in science, mathematics, and technology (AAAS, 2011). Through Project 2061, the AAAS conducts research and develops tools and services which it then makes available to educators, researchers, and policymakers. Project 2061 began its work in 1985, the year that Halley’s Comet was last visible from Earth. Supporters of Project 2061 noted that children starting school now may see the return of the comet in 2061 which serves as a reminder that today’s education will shape the quality of their lives as they come of age in the 21st century amid profound scientific and technological change (AAAS, 2011).

Current standards-based, educational reform efforts require “...a substantive change in how science is taught; an equally substantive change … in professional development practices” (National Research Council, 1996, p.56). In response to this call for reform in science education for younger children, the current study focused on: (a) the factors that influence elementary school teachers’ ability to teach science well; and (b) how these factors may impact their classroom practices. A central feature key to understanding teacher practice is that of teacher beliefs (Richardson, 1996; Simmons et al, 1999), and in response, this study endeavored to examine patterns in beliefs that elementary school classroom teachers may have about teaching science effectively.

**Effective Inquiry-Based Classroom Practices in Science Education**

During the past two centuries, our understanding of the natural world and its complexities has expanded, resulting in the development of new concepts as well as an array
of revolutionary ideas about the nature of science (Dana, Campbell, & Luneta, 1997). During this time period, science teaching also changed dramatically as educational researchers investigated new science learning and teaching methods (DeBoer, 1991; Ulich, 1967). Understanding the process of science learning as it occurs in a classroom, however, is a complex task, and can be left open to many interpretations.

Educational philosopher John Dewey discussed how education placed too much emphasis on facts and not enough emphasis on the development of thinking skills and attitudes of the mind (Barrow, 2006). A former science teacher, Dewey recommended that inquiry be included in kindergarten through twelfth grade science curriculum. In his book, *How We Think* (1910), Dewey observed that “the most casual notice of the activities of a young child reveals a ceaseless display of exploring and testing activity” (p. 31). Dewey encouraged K–12 teachers of science to use inquiry as a teaching strategy. Barrow (2006), a Harvard educational researcher, noted that in Dewey’s model, the student is actively involved, and the teacher serves as a facilitator and guide. In 1916, Dewey encouraged teachers to show students how to add to their personal knowledge of science by addressing more realistic problems and applying “observable phenomenon” (Barrow, 2006, p. 266) to these problems.

According to Webster’s Third International Dictionary (Gove, 1986), *inquiry* is an “act or an instance of seeking for truth, information, or knowledge; investigation; research; or a question or query” (p. 1167), while the root word *inquire* means “to ask for information about, to make an investigation or search, to seek information or questioning” (p. 1167). In its most simplistic form, inquiry asks others to make their thinking process visible. It is not a new technique. Considering ancient Western culture, Socrates, Aristotle and Plato were all
masters of the inquiry processes. That heritage has given us modes of teaching in which students are vitally involved in the learning and creating processes.

For the past 100 years, science education researchers (Bybee & DeBoer, 1993; DeBoer, 1991) have explored the role of inquiry in school science programs and current science education reforms. Inquiry-based learning, as opposed to more traditional didactic methods, places less emphasis on whole-class lessons and text-book instruction. Inquiry into the natural world takes a variety of forms; it can range from a child’s wondering how it is possible for squirrels to climb trees to a search by groups of physicists for new atomic particles. Studies have continued to demonstrate that an inquiry-based, hands-on approach is an effective method to teach science in a world where “facts change frequently and the difficulty of the issues faced increases with time” (Garcia, 2004, p. 24). In fact, the National Science Education Standards proposed by the AAAS (1993) and the NRC (1996) have recommended that science education be restructured around inquiry.

Although it is generally accepted that traditional didactic elementary science programs offer students opportunities to develop process skills such as recording data, communicating, and measuring, Mastropieri and Scruggs (1994) have suggested that the higher level process skills of predicting, inferring, hypothesizing, and experimenting may occur more easily in activity–based experiences; they noted that these activity-based activities occur in inquiry-based instructional environments. According to Maker (1982), reasoning skills are encouraged when teachers’ instructional methods lead to classroom activities that provide opportunities for students to (a) abstract, conceptualize and synthesize; (b) see similarities, patterns and differences; (c) generalize from one situation to another; and (d) find pleasure in an intellectual activity.
Teaching and learning science as inquiry is recognized by the National Science Education Standards (NRC, 2000) to include five essential features: (a) the learner engages in scientifically oriented questions; (b) the learner gives priority to evidence in responding to questions; (c) the learner formulates explanations from evidence; (d) the learner connects explanations to scientific knowledge; and (e) the learner communicates and justifies explanations (NRC, 2000, p. 29). The National Science Education Standards seek to promote curriculum, instruction, and assessment models that enable teachers to build on children’s natural, human inquisitiveness. The goal is for teachers to encourage students to understand science as a human endeavor, to acquire the scientific knowledge and thinking skills important in everyday life and, if the students so choose, to pursue a career that falls within the fields of science, technology, engineering and mathematics (STEM).

Researchers (Haury & Rillero, 1992) have investigated the benefits to students of a more activity-based, inquiry-oriented approach to science teaching. They used qualitative survey methodology to assess elementary and middle school teachers’ beliefs concerning hands-on science teaching and learning. Science curriculum coordinators and educational researchers were also included in the sample. Participants’ responses included their names, grade levels taught, and professional affiliations. Researchers concluded that students in inquiry-based programs increased their creativity and developed improved attitudes toward science, communication skills, and reading readiness (Haury & Rillero, 1992).

Self-efficacy and Teachers’ Behaviors in the Classroom

Unfortunately, little is known about when, why, and how practicing teachers support or hinder students’ scientific inquiry practices in general (Avraamidou & Zembal-Saul, 2005; Davis, Petish, & Smithey, 2006; Keys & Bryan, 2001). Smolleck, Zembal-Saul and Yoder
(2006) hypothesized that elementary teachers’ lack of science training may be an issue. They found that, especially at the elementary level, teachers who lack personal experience with learning science through inquiry find it difficult to provide effective science instruction to their students.

Rotter (1966) explored the connection between self-efficacy and teacher behaviors in the classroom. Bandura (1981) found that teachers’ behaviors in any given instructional task are the products of teachers’ attitudes, which are influenced by their self-efficacy regarding that task. However, the effect of self-efficacy on teacher behavior and student achievement for pre-service teachers has been researched extensively (Pajares, 1992; Schunk, 1987; Tschannen-Moran, Woolfolk-Hoy, & Hoy, 1998). Guskey (1981) found that teachers’ self-efficacy predicted their goals and aspirations, attitudes toward innovation, change and evaluation, and use of teaching strategies and efforts.

Smolleck et al. (2006) discussed the important relationship that exists among beliefs, attitudes and behaviors, suggesting that the relationship between self-efficacy and inquiry science teaching must be explored more fully. They developed the Teaching Science as Inquiry (TSI) instrument, based upon previous self-efficacy work (Bandura, 1977, 1981, 1989, 1995, 1997; Enochs & Riggs, 1990; Riggs, 1988; Riggs & Enochs, 1990). The TSI is a 69-item Likert-scale instrument designed to assess the self-efficacy beliefs of pre-service elementary teachers regarding the teaching of science as an inquiry process. The TSI was administered in a university setting to 190 prospective elementary school teachers in six sections of an undergraduate science methods course at the beginning of the semester and then again at the end of the semester. The researchers reported that the TSI appeared to be a valid instrument with high to moderate internal reliability and high to moderate test-retest
reliability for use with pre-service elementary education teachers, but they suggested that further construct validity tests were needed. The intended population was pre-service elementary science teachers and beginning practicing science teachers; a second instrument, developed for more experienced elementary teachers, has not yet been fully piloted (L. Smolleck, personal email communication, January 26, 2010). Smolleck et al. (2006) concluded that there the need exists for further exploration into “how self-efficacy may affect eventual classroom practices” (p. 158). The current research explored how inquiry-based science classroom instructional methods, and specifically, questioning and thinking, are influenced by the science self-efficacy of practicing elementary school teachers.

**Questioning and Thinking Skills**

This study explored the manner in which elementary school teachers’ self-efficacy may predict the frequency of high-level questioning methods, or higher order thinking skills. Most importantly, it offered opportunities for elementary school teachers to freely discuss approaches that they found successful and to identify the areas with which they struggle in teaching science.

The process of knowledge construction in any discipline is dependent upon language and discussion (Dillon, 1994; Lemke, 1990). There is no doubt that questioning is a significant part of teaching and science talk. In fact, the National Science Education Standards have emphasized *authentic student-generated questions* as an effective central strategy for teaching science (National Research Council, 1996). To this end, McLaughlin and Talbert (1993) conducted a longitudinal qualitative research study of 16 California and Michigan high schools, exploring the topic of professional reform. Findings suggested that, although both lower-order and higher-order thinking skills undoubtedly play a role in any
classroom, students of teachers who can convey higher-order thinking skills outperform students whose teachers are only capable of conveying lower-order thinking skills.

Sociolinguist Hugh Mehan (1979) is credited with uncovering the common teacher-student discourse format *IRE* (Initiation – Response – Evaluation) that typically consists of three moves—initiation (often via a teacher question), student response, and teacher evaluation (Mehan, 1979). Early researchers Lev Vygotsky (1978) and Jerome Bruner (1986) suggested that the *IRE* dialogue benefits students if teachers can extend students’ knowledge through further exploration and understanding of a particular topic. Later researchers (Lemke, 1990; Sawyer, 2001) asserted that teacher and student critical questioning strategies lead to a more constructivist classroom atmosphere.

Research (vanZee et al., 2001) has focused on identifying the types of questioning patterns that teachers use during science conversations. Participants in this qualitative case study included two primary teachers, an upper elementary teacher, a high school physics teacher, a university researcher, and their students with recorded information collected over the course of an academic year. The researchers documented and interpreted teacher/student questions during guided discussions, student-generated inquiry discussions and collaborations. The researchers found that teachers elicited student thinking by: (a) asking questions that developed conceptual understanding; (b) practicing quietness through longer wait times; (c) encouraging attentive silence; and (d) demonstrating reticence to provide answers.

Chin (2006) examined question-based discourse practices in science classrooms through the interactions between teachers and students across a number of activities in order to identify ways in which teachers followed up on students’ responses to questions.
Purposeful sampling was employed so that the researcher could utilize motivated students who ranged from average to above average ability. The average class size was 40 students per class. Fourteen audiotaped or videotaped lessons of one hour each focused on the following science topics: (a) mass, volume, and density, (b) elements, mixtures, and compounds, (c) photosynthesis, and (d) respiration. Chin (2006) found that by using her analytical framework, Questioning-based Discourse, student responses and thinking were enhanced. She analyzed the nature of the student response, which in turn influenced the teacher’s feedback and follow-up questions. She also reported that teachers’ questions served to scaffold students’ thinking and move students toward conceptual development instead of just assessing how correct they were. Chin noted that teachers can make their classroom discourse more thought-provoking and stimulate more elaborate and productive student responses by encouraging turn-taking and discourse patterns other than the traditional IRE sequences (2006).

These researchers (Chin, 2006; Lemke, 1990; Sawyer, 2001; vanZee et al., 2001) have illustrated the fact that teacher questioning may elicit information to assess students’ understanding of subject content and encourage classroom dialogue, which in turn may play a role in student understanding. The language of science is more complex than simply being able to verbalize the appropriate words, phrases, and scientific terminology, and continued research is needed to assist teachers in understanding and implementing strategies that foster meaningful and inquiry-based science learning.

**The Beliefs, Knowledge, and Attitudes that Influence Teacher Behavior**

Researchers (Abelson, 1979; Bandura, 1986; Nespor, 1987; Pajares, 1992; Richardson, 1996) have reported that teachers frequently form early self-perpetuating beliefs
about learning that may affect their future instructional behaviors. Other researchers (Bandura, 1986; Ford, 1992; Garcia, 2004; Koballa & Crawley, 1985; Lumpe et al., 1999; Pajares, 1992) have demonstrated that teachers’ attitudes can powerfully influence students’ science learning experiences. By improving teachers’ attitudes toward science teaching, students may receive appropriate science instruction, which can create more meaningful and positive scientific understandings.

The next section continues with a discussion of teacher beliefs and knowledge, the nature of science and how the constructs of motivation, competence and achievement affect teacher attitude, thereby affecting teacher behavior. It concludes with an explanation of self-efficacy and in particular, science self-efficacy and its relationship to elementary school teachers’ classroom science instructional practices.

**Teacher beliefs.** For years, researchers have explored teachers’ beliefs about teaching itself in order to improve instructional methods. Early researchers (Bandura, 1986; Rokeach, 1968) concluded that individuals make decisions based on what they believe. Based on these findings, later researchers such as Nespor (1987) and Pajares (1992) have suggested that teacher behaviors can best be understood by focusing on the things that teachers believe and how these opinions evolve.

Early research (Nespor, 1985, 1987; Pajares, 1992; Richardson, 1996) on teacher beliefs explored their direct influence on teachers’ professional practices. Teachers’ beliefs continue to be the subject of current educational research, with topics such as the importance of their role in engaging teachers with specific science teaching practices such as inquiry (Fishman et al., 2003; Lotter et al., 2007; Roehrig et al., 2007).
In a seminal study designed to investigate the influence of beliefs on practice, Nespor (1985, 1987) built on Abelson’s (1979) work on artificial intelligence systems. In his 1985 study, Nespor conducted, videotaped, and analyzed 20 hours of interviews with eight teachers from three different districts using stimulated recall and repertory grid techniques. These teacher interviews were conducted over the course of a semester and included a total of approximately 4 hours of class time. Nespor (1985) analyzed teachers’ beliefs about teaching, coding them into three categories: the effects of subject matter conceptions, career influences, and experience on teaching practices. Nespor (1985) noted that:

...teaching is an “entangled domain”...because of the great diversity of settings within the domain—different schools, different grade levels, different subject matter areas, … because teacher experience multiple manifestations of these settings in the course of their careers. To manage these difficulties, teachers rely on loosely bounded conceptual systems (beliefs) which help them define tasks where the situation itself presents no clear task or no feasible task (p. 171).

In his later work, Nespor identified four individual characteristics of teacher beliefs (1987). The first, existential presumption, refers to the deeply held personal truths that everyone holds about the situations they experience. For example, a teacher may believe that in order to learn science, one must be drilled on definitions. The second, alternativity, refers to an individual’s attempt to create the ideal, such as having a utopian classroom life view created from a past history of a difficult and traumatic teacher experience. Nespor (1987) suggested that beliefs have stronger affective and evaluative components, his third characteristic, and these typically operate independently from actions associated with knowledge. He explained that, as with Bandura’s (1986) self-efficacy beliefs, affect and
evaluation can join forces to determine just how much energy and in what manner a teacher will spend on teaching a particular concept. Nespor (1987) further stated that beliefs are stored in our *episodic memory*, the fourth characteristic, with material drawn from personal experiences. According to Nespor (1987), all four characteristics play into teacher belief systems, drawing power and wielding control over their understanding of future events.

Pajares (1992) argued that attention to teacher beliefs can inform educational practice and stated that “belief is based on evaluation and judgment; knowledge is based on objective fact” (p. 316). He also noted that when researchers describe teacher beliefs, they are not referring to teachers’ broader general belief system, but rather to their educational beliefs (Pajares, 1992). In addition to Nespor (1987), Pajares (1992) explored the teacher belief research of Abelson (1979) and Bandura (1977, 1981), among others, to arrive at a series of fundamental assumptions, noted below.

First, beliefs are formed early and will self-perpetuate, even when set against contradictions raised by time, schooling or experience (Abelson, 1979; Nespor, 1987; Rokeach, 1968). Second, an individual’s beliefs strongly affect his or her behavior (Abelson, 1979; Bandura, 1986; Nespor, 1987; Rokeach, 1968). Third, beliefs and knowledge are strongly connected, but the affective, evaluative and episodic nature of beliefs create a filter through which new information is interpreted (Abelson, 1979; Nespor, 1987; Rokeach, 1968).

**Science content knowledge.** Researchers recognize that a teacher’s ability to transfer science knowledge is an integral component necessary for any successful science program implementation. Research has demonstrated that, to be effective, teachers need to develop their own content knowledge, beliefs in their own abilities, and effective
instructional practices for guiding students’ explanations about scientific complexities (Haefner & Zembal-Saul, 2004; Newton et al., 1999). However, teachers encounter numerous challenges when helping students develop these evidence-based science explanations (Geddis, 1991; Newton et al., 1999). For example, novice elementary school teachers often face particular challenges due to their limited science subject matter knowledge and lack of teaching experience.

Research has suggested that teacher knowledge includes three important constructs: subject matter knowledge, pedagogy knowledge, and beliefs about how children learn science (Shulman, 1986). In a seminal study, Shulman (1986) utilized qualitative case study and interview research to focus on the development of six novice California secondary teachers in English, biology, mathematics, and social studies. He followed these teachers for two years, focusing on the sources of teacher knowledge: what, how and when teachers know information; how new knowledge is acquired and old knowledge retrieved; and how teachers combine all of the above to create a new knowledge base. Shulman concluded that it is useless for teachers to possess content knowledge alone or excellent teaching skills that lack content. Shulman cautioned that the housekeeping aspects of teaching, such as classroom management and lesson planning, often take precedence over what is being taught, what questions are being asked, and what explanations are given (Shulman, 1986).

**Pedagogical content knowledge.** In Shulman’s (1986) conceptual analysis, teacher knowledge is based on content knowledge (how much and the way in which a teacher thinks about science, for example), which can be divided into three categories: (a) subject matter knowledge (not only defining accepted truths, but how and why it relates, and why is it worth knowing), (b) pedagogical knowledge (ways of teaching a subject so that others can
understand it), and (c) curricular knowledge (a lateral and vertical understanding of what is to be taught). Shulman’s work on teacher knowledge resulted in the term, *Pedagogical Content Knowledge* (PCK) (1986). PCK encompasses reflection on both the content and practice of teaching, and within the content, “knowledge of the structures of one’s subject, pedagogical knowledge of the general and specific topics of the domain, and specialized curricular knowledge” (Shulman, 1986, p. 13). Shulman concluded with a call for teacher education programs that accommodate both process and content supported by case literature that “represent a far wider and more diverse range of teaching contexts” (Shulman, 1986, p. 14).

**Nature of science.** A factor that may influence teacher knowledge relates to the nature of science (NOS). The National Science Teachers Association (2011) has suggested that NOS includes an understanding and awareness that: (a) scientific knowledge is both reliable and tentative; (b) science is complex, meaning that there are numerous shared values and perspectives and a variety of scientific paths that have led to an understanding of nature; (c) creativity is both important and personal in understanding scientific principles; (d) supernatural elements cannot be a part of producing scientific knowledge; (e) the primary goal of science is the formation of theories and laws (crucial difference exists between observations and inferences); (f) scientific questions, observations and conclusions in science are influenced by the existing state of scientific knowledge and the observers’ experiences (social and cultural contexts); (g) the history of science contains evolutionary and revolutionary changes; and (h) although technology impacts science, the goal is an understanding of the natural world for its own sake.

Akerson, Hanson and Cullen (2007) conducted research that suggested how difficult it may be to influence teachers’ understanding of NOS. Fourteen kindergarten through sixth
grade elementary teachers with varied science content backgrounds from three high-need school districts participated in a 2 week summer workshop. In the morning, participants attended content-focused sessions on physics, and in the afternoon, participants attended sessions focused on NOS. The participants’ conceptions of the NOS were assessed both pre- and post-workshop using the Views of Nature of Science Elementary School Version 2 (VNOS-D2; Lederman & Khishfe, 2002). Seven teachers (approximately 30%) were selected for interviews prior to and after workshop participation. Videotapes were made of the daily sessions and reviewed to ensure that explicit and reflective NOS instruction occurred. A matrix was used to organize survey results and interview responses to check for congruence.

Akerson et al. (2007) concluded that, although the majority of participants changed their ideas about the nature of science, misconceptions still existed. For example, some of the participants still considered the scientific method and science itself, for that matter, to be just another discipline that had no connection to everyday understandings of the world around them.

**Teacher attitudes.** Early research suggested that teachers’ attitudes toward science influenced their students’ attitudes (Washton, 1971). Koballa and Crawley (1985) defined science attitude as a “general and enduring positive or negative about science” (p. 222). They made a distinction between “I like science,” which is a positive attitude, and “Science is too mathematical,” an acquired negative attitude (Koballa & Crawley, 1985). The authors concluded by noting that this learned attitude toward science can create either positive or negative feelings, important because these feelings predict science-related behaviors (Koballa
and subseqent behavior in science teaching.

Beliefs, according to Bandura (1986), are the driving force behind the decisions that individuals make throughout their lifetimes. Pajares (1992) stated that a group of beliefs that surround a particular situation result in the formation of an attitude. Bandura (1997) stated that it is difficult to influence individuals to behave in ways that go against the attitudes they have held for long periods of time, which suggests that the link between attitudes and behavior is strong; attitudes may be based on experiences, and behavior in certain situations is based on these experiences. Bandura continued by noting that “Evidence suggests that both attitudinal and behavioral changes are best achieved by creating conditions that foster desired behavior” (Bandura, 1997, p. 513).

Garcia (2004) conducted qualitative survey research to explore the relationship between teacher attitude and science instruction in inquiry-based science. Garcia’s (2004) participants (n = 13) included kindergarten through fourth grade male and female teachers who taught science, in addition to other subjects, in both public and private elementary settings. Interestingly, 11 of the 12 respondents reported that, although they liked science and believed they were competent at teaching in general, they did not consider themselves competent science teachers. When asked to rank barriers to effective science learning in descending order, they reported: lack of time (30%), insufficient materials/supplies and unstructured classroom resources (21% each), classroom management (15%), and inadequate collegial support (13%). Garcia (2004) concluded that, although respondents reported that they had good science content knowledge, they reported feeling inadequate as science teachers, possibly because schools place more emphasis on science concepts rather than on
how science is actually taught. Garcia also noted that some of the teachers did not believe
that they were good science teachers, an interesting comment relating to the teachers’ sense
of self-efficacy.

As previously noted (Koballa, 1992; Pajares, 1992), beliefs that surround a particular
situation form attitudes, and the attitudes held toward a particular situation guide behavior
and decision making. Ford (1992) defined these beliefs as evaluative beliefs, categorizing
them as: capability beliefs (beliefs teachers have about their ability or skill to be good science
teachers) and context beliefs (beliefs that teachers have about the external factors that either
help or hinder them in their teaching of science). Lumpe et al. (1999) noted that Ford’s
research (1992) into context beliefs defines “the connection between a person’s actions and
the context’s response to the action” (Lumpe, et al., 1999, p. 278). More simply, science
teaching outcome expectancy refers to a teacher’s belief that more effective science teaching
helps students learn science.

In their quantitative study that focused on assessing teachers’ context beliefs about
their science teaching environment, Lumpe et al. (1999) developed an instrument to measure
teachers’ perceptions of their schools’ science programs. The authors interviewed 130
kindergarten through twelfth grade science teachers with varying levels of experience for the
initial pool of items for the Context Beliefs about Teaching Science (CBATS) instrument.
The items were based on reform themes identified by the Biological Sciences Curriculum
Study (BSCS) that included constructivism, cooperative learning and the nature of science.
The diverse responses to the open-ended questions for each of the reform themes were
combined, and only those that accounted for 75% of the categories were included. Content
validity was established with the interview answers from the science teachers.
One large urban school district, several suburban and several rural districts from a mid-western state participated in the next phase. The instrument was pilot-tested by 71 teachers, 78% of whom were women. Construct validity was partially determined using factor analysis. The CBATS instrument scores were correlated with the self-efficacy and outcome expectancy scores as measured by the STEBI, although the authors expected that the CBATS scores would be more highly correlated with outcome expectancy than with self-efficacy.

Lumpe et al. (1999) found that continued research is needed with the CBATS instrument to profile personal agency belief patterns of science teachers. They noted that the number of years of teaching may be positively related to context belief. They also found that professional development must increase teachers’ motivation to become more effective teachers and address the teaching context. And finally, they found that self-reflection can lead to goal modification. Future research might identify teachers’ personal agency belief patterns and the role they play in science teaching effectiveness (Lumpe et al., 1999).

In conclusion, this section has focused on teachers’ attitudes and assessment methods suggested by researchers who hope to understand how teacher beliefs influence teachers’ attitudes in science teaching. The next section continues by exploring how motivation is also influenced by attitudes, which in turn, influences learning and ultimately, behavior.

**Motivation, Competence and Achievement**

Theories of behavior enable researchers to understand why people act in a particular way. A historical overview of the field of behavior would be incomplete without noting important key theories with thumbnail sketches of various theorists as reference points along
the way. Table 1 highlights important behavioral theorists who have made major contributions to our understanding of behavioral psychology.
Table 1

*Behavioral Theorists*

<table>
<thead>
<tr>
<th>Theory</th>
<th>Period</th>
<th>Theorist(s)</th>
<th>Summary</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychoanalytic Theory</td>
<td>1900-1930</td>
<td>Sigmund Freud</td>
<td>Focus on physiological and instinctual needs. Everything we do, every thought we have, and every emotion we experience has one of two goals: to help us survive or to prevent our destruction.</td>
<td>Freud, 1901</td>
</tr>
<tr>
<td>Behaviorism: Drive Theory</td>
<td>1940-1960</td>
<td>Clark Hull</td>
<td>Our biological needs cause us to act in ways that restore our equilibrium.</td>
<td>Hull, 1943</td>
</tr>
<tr>
<td>Field Theory</td>
<td>1940-1960</td>
<td>Kurt Lewin</td>
<td>All behavior is a function of both the person and the environment.</td>
<td>Lewin, 1951</td>
</tr>
<tr>
<td>Social Learning Theory</td>
<td>1940-1960</td>
<td>Julian Rotter</td>
<td>We choose behavior that we think will lead to the most personally rewarding goals.</td>
<td>Rotter, 1954</td>
</tr>
<tr>
<td>Effectance Motivation Theory</td>
<td>1959</td>
<td>Robert W. White</td>
<td>We actively work to develop ourselves.</td>
<td>White, 1959</td>
</tr>
<tr>
<td>Achievement Motivation Theory</td>
<td>1960-1980</td>
<td>John Atkinson</td>
<td>Two separate motives exist in humans: to achieve success and to avoid failure, as it leads to shame and anxiety.</td>
<td>Atkinson, 1957</td>
</tr>
</tbody>
</table>
### Table 1 (continued)

**Behavioral Theorists**

<table>
<thead>
<tr>
<th>Theory</th>
<th>Period</th>
<th>Theorist(s)</th>
<th>Summary</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Causation Theory</td>
<td>1968</td>
<td>Richard deCharms</td>
<td>We choose our own behavior rather than being forced to act a certain way out of fear or because of a reward.</td>
<td>deCharms, 1968</td>
</tr>
<tr>
<td>Attribution Theory</td>
<td>1970-1990</td>
<td>Fritz Heider, B. Weiner and H.H. Kelly</td>
<td>Based on Heider’s original work, the theory states that world events and behavior are caused by personal and environmental forces and that when individuals set goals this leads to accomplishments.</td>
<td>Heider, 1958</td>
</tr>
<tr>
<td>Self-Determination Theory</td>
<td>1975- present</td>
<td>Edward Deci and Richard Ryan</td>
<td>We have psychological needs for competence, autonomy and relatedness, and intrinsic motivation develops from these needs.</td>
<td>Deci &amp; Ryan, 1985</td>
</tr>
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<td>Self-Determination Theory</td>
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<td>We have psychological needs for competence, autonomy and relatedness, and intrinsic motivation develops from these needs.</td>
<td>Deci &amp; Ryan, 1985</td>
</tr>
<tr>
<td>Flow Theory</td>
<td>1979- present</td>
<td>Mihaly Csikszentmihalyi</td>
<td>Pure intrinsically motivated behaviors involve enjoyment, complete immersion in the activity, focus and feelings of competence.</td>
<td>Csikszentmihalyi, 1990</td>
</tr>
</tbody>
</table>
Teachers’ motivation and views of their own competencies may be inter-related. Motivational theorists (Atkinson, 1957; Eccles, Wigfield, & Schiefele, 1998; Dweck & Elliot, 2005; Shulman, 1986) have suggested that motivation has an effect on the development of self-efficacy and may also influence choice, persistence, and performance. In Eccles et al. (1998) Model of Achievement and Motivation, individuals’ expectancies and values are assumed to directly influence their task performance, persistence in a task, and selection of a task. Task-specific beliefs such as perceptions of competence and the difficulty of different tasks influence individuals’ expectancies and values, and eventually, goals. In other words, individuals tend to ask themselves three basic questions: (a) Can I succeed at this task? (b) Do I want to do this task? and (c) Why am I doing this task? The answers to these questions influence teachers’ motivation, which then impacts teachers’ attitudes toward innovation and change.

Dweck and Elliot (2005) defined the need for competence as a “fundamental motivation that serves the evolutionary role of helping people develop and adapt to their environment” (p. 6). This need for competence encourages behaviors that seek achievement opportunities. A recent motivation study (Pop, Dixon, & Grove, 2010) exemplifies this point. The study investigated the views of elementary, middle, and secondary-education teachers by following their participation in the Research Experiences for Teachers (RET) Program. Pop et al. (2010) described teachers’ attendance at the RET workshops as a type of cognitive apprenticeship, for teachers play the role of students in the learning process in order to acquire the skills and knowledge relevant to the practice of science.

The target sample consisted of 90 teachers, all RET participants from 1999 to 2006. The research was conducted in two phases. First, a demographic questionnaire and three
additional questionnaires (i.e., Motivation to Attend the RET Program Questionnaire, Expectations about the RET Program Questionnaire, and Changes to Teaching Practices Questionnaire) were administered. Descriptive statistics (e.g., counts, percentages, means, and standard deviations) were used to report survey results. Also, a one-way analysis of variance (ANOVA) was used to determine whether significant differences existed in teachers from different grade levels on motivation, expectancies, and changes to teaching practices (Pop et al., 2010). In the second qualitative phase of the study, a total of 12 participants were selected from survey respondents to participate in a telephone interview about their RET experiences. The data were qualitatively coded and analyzed.

Pop et al. (2010) found that most teachers who attended the RET program were intrinsically motivated to do so; specifically, the stated reasons for attendance included: (a) gaining new teaching ideas (82.9%, \( n = 29 \)), (b) growing professionally (77%, \( n = 27 \)), (c) understanding how to implement changes to classroom teaching (57.1%, \( n = 20 \)), and (d) gaining content knowledge (54.3%, \( n = 19 \)) (Pop et al., 2010). Researchers reported that elementary-school teachers also wanted to learn more science due to their perceived lack of science content knowledge and lack of confidence in science teaching. These elementary-school teachers believed the RET program would help them overcome these deficiencies.

ANOVA results (\( p < .05 \)) indicated that elementary teachers implemented more changes than their middle school counterparts as follows: (a) they made more general changes to their instructional strategies than middle school teachers (\( M = 3.17, SD = .56 \)); (b) they increased their use of student-centered teaching approaches (\( M = 3.23, SD = .64 \)); (c) they used more experiments than before (\( M = 3.29, SD = .75 \)); (d) they conducted more hands-on activities (\( M = 3.31, SD = .63 \)); (e) they offered more collaborative learning
activities ($M = 3.34, SD = .63$) ; (f) they utilized more applied science strategies in teaching; (g) they utilized more inquiry in teaching ($M = 3.46, SD = .70$); and (h) they demonstrated more self-confidence in teaching science ($M = 3.37, SD = 3.37$) (Pop et al., 2010).

Overall, science teachers may not perceive themselves as competent. Harlen, Holroyd and Byrne (1995) conducted a seminal 1995 U.K. study in four phases to examine science instruction in primary schools. In the first and second phases of the study, 514 primary level teachers responded to a questionnaire, and 57 of these teachers were interviewed concerning their science and technology views. In the third and fourth phases, 33 teachers kept notes on their teaching of science and technology and discussed these with the researchers by telephone, and 30 members of educational programs at various universities and education authorities were interviewed about the training of initial and in-service primary school teachers (Harlen et al., 1995).

Harlen et al. (1995) reported that primary level teachers described less confidence about teaching science and technology than almost any other curriculum area, but more confidence about the biological sciences. Interestingly, they reported more confidence about developing students’ science process skills but less confidence about developing students’ science content knowledge. Male teachers reported having more confidence than female teachers, and recently qualified primary level teachers were more confident than those with more years of experience. Those teachers with more science qualifications were more confident than those with fewer qualifications, and although many teachers reported high general professional confidence, they were not confident that their own understanding of science was enough to facilitate their students’ conceptual science development (Harlen et al., 1995).
Twelve years later, Colette Murphy, Peter Neil and Jim Beggs (2007) conducted a second large scale U.K.-wide survey of primary level teachers’ science teaching and compared their results with those from the earlier Harlen Report (1995). Using quantitative and qualitative methodologies, Murphy et al. (2007) explored primary level teachers’ confidence and the impact of recent science education reforms. They conducted telephone interviews with 300 primary teachers from across the U.K. and held seven focus groups of primary teachers to further explore the issues raised in the telephone interviews. In addition, they held a 2-day conference with more than 75 teachers, teacher educators, curriculum developers, and policy makers involved in primary science education. Electronic surveys were distributed to 100 teacher education institutions involved in primary level science education.

Several qualitative themes emerged from the focus group discussions that had not been shared during telephone interviews. The authors noted that only 23% of younger teachers (in their twenties) reported that lack of science knowledge/experience/confidence training was an important issue, but, a greater percentage of older teachers noted it as a problem (50-60%). Teachers reported less confidence in their ability to teach science (80%) than their abilities to teach math (95%) or English (88%). In addition, only 66% of teachers’ reported being confident in their ability to help children relate science to their everyday lives. Teachers reported feeling more confident in their questioning skills (86%), compared with those using information and communication technology (44%). Teachers’ confidence in developing children’s understandings of science concepts indicated that they were most confident teaching about a flowering plant (85%), water cycle (85%), basic life processes (82%), but less confident about sound travel (69%), reflection of light (68%), how we see
things (67%) and friction (66%). This finding was consistent with previous *Harlen Report* research findings (1995), in which teachers reported less confidence in physical science topics as compared to biological ones (Harlen et al., 1995; Murphy et al., 2007).

Murphy et al. (2007) conducted an ANOVA with the survey data to explore factors that may influence teachers’ confidence in their science teaching. The authors reported the strongest correlations existed “for the relationships between confidence in their own teaching abilities and professional development undertaken in science and that between confidence and the size of the school– teachers from larger schools were more confidant” (2007, p. 424). Professional development topped the list of factors affecting teacher confidence. The analysis revealed a smaller relationship between teacher confidence and gender, age, additional funding for science and location (urban, suburban and rural), and time spent teaching science (Murphy, et al., 2007).

In conclusion, motivation, competence and achievement may affect teachers as they struggle to support successful science learning. Researchers (Dweck & Elliot, 2005) have suggested that competence is at the core of self-concept and self-esteem, and it is a basic psychological need that has a pervasive impact on our thoughts and behaviors, both personal and professional. The next section discusses the impact which task-specific confidence has on understanding teachers’ thoughts and behavior.

**Self-Efficacy**

General teaching efficacy relates to teachers’ beliefs that teaching influences student learning, whereas personal teaching efficacy represents teachers’ beliefs in their own abilities to affect student learning (Allinder, 1994). Personal teaching efficacy affects teachers’ attitudes, which in turn affects teachers’ behaviors. The effect that efficacy has had on
teacher behavior and student achievement has been researched extensively (Pajares, 1992; Schunk, 1987; Tschannen-Moran et al., 1998).

In his seminal article, *Generalized Expectancies for Internal Versus External Control of Reinforcement*, Rotter (1966) outlined the concept locus of control formulation, which classified generalized beliefs concerning who or what influences behavior as internal control (the belief that the control of future outcomes has to do with the individual) and external control (the belief that control is outside of oneself, in the hands of those more powerful or due to fate/chance) (Rotter, 1966). Tschannen-Moran et al.’s (1998) teaching analogy helped to explain internal and external control. If teachers feel that their teaching environment overwhelms their ability to have an impact on student learning, they exhibit external control, as opposed to teachers who express confidence in their ability to teach students, which is an example of internal control (Tschannen-Moran et al., 1998).

Drawing on Rotter’s (1966) work, the RAND Corporation funded a ground-breaking research project in California by Armor et al. (1976) to assess the 1972 *School Preferred Reading Program*. The researchers developed and administered a questionnaire to 81 teachers in the Los Angeles Unified School District (LAUSD); they also collected data from student longitudinal records and interviews with principals and specialists from 20 elementary schools in districts located in low-income ethnically diverse neighborhoods. The majority of items in the survey focused on district policy variables rather than teacher–student interactions. However, two items did focus on teacher attributes and self-efficacy (Armor et al., 1976). These two survey items read as follows: (a) “When it comes right down to it, a teacher can’t do much (because) most of a student’s motivation and performance depends on his or her home environment” and (b) “If I try very hard, I can get through to
even the most difficult or unmotivated students” (Armor et al., 1976, p. 23). Researchers combined the responses to the statements into a single measure of efficacy defined as “the extent to which the teacher believes he or she has the capacity to produce an effect on the learning of students” (Armor et al., 1976, p. 23). They reported:

The more efficacious the teachers felt, the more their students advanced in reading achievement. The measure was strongly and significantly related to increases in reading. Our finding that efficacy affects achievement, demonstrates the importance of these pre-dispositional factors for effective teaching. (Armor et al., 1976, pp. 23–24)

Bandura (1977) identified self-efficacy as a powerful force in learning and motivation, as well as teacher beliefs. In 1977, Bandura published *Self-efficacy: Toward a Unifying Theory of Behavioral Change*, in which he described a model to be used in the treatment of adults with snake phobias. He assigned each of his adult participants who were snake phobics (n =10) to one of three treatment groups: the participant modeling group, consisting of phobics who directly engaged in holding snakes after a brief self-mastery period; the modeling alone group, consisting of phobics who merely observed others holding snakes; and the control group who received no specialized treatment. Together with pre- and posttests, subjects were measured at different intervals considered critical by the researchers. Using a list of 18 performance tasks ranked in order of increasing threats, participants rated the strength of their expectations for each task on a 100-point probability scale.

Bandura (1977) found that experiences based on the performance accomplishments (such as handling the snakes), produced higher, generalized, and stronger efficacy
expectations than those that relied on modeling and observation experiences alone, which in turn exceeded those in the control group. He proposed that the development of expectations of personal efficacy or self-efficacy derives from four contributors: successful performance (personal experiences), vicarious experience (observing the experiences and suggestions of others), verbal persuasion (someone tells you how you are doing something) and emotional arousal (your emotional or physical reaction to the aspects of a particular situation) (Bandura, 1977). His resultant theories on self-efficacy were based on several constructs of human behavior (Bandura, 1977). He noted that cognitive processes are a part of how one acquired and maintained new ways of behaving in different situations and that behavior is modeled based on what one sees others do. Individuals also have self-corrective abilities that further refine their actions (Bandura, 1977).

Bandura (1977) also made the distinction between efficacy expectations and response-outcome expectancies, which relate to each other. This distinction can be explained based on what teachers believe about teaching when assessing their own performance in the classroom. For example, teachers may provide instruction on the water cycle to their students (efficacy expectation), and they then hope that their instruction will be effective at increasing students’ understanding of the topic (response--outcome expectancy) (Bandura, 1977). Self-efficacy is distinct from other self-concepts such as self-worth and self-esteem, as it is specific to a particular task or a more personal belief about our ability to cope with a particular situation.

Bandura (1977) also presented his theory of perceived self-efficacy, which states that individuals avoid difficult situations when they think that they cannot cope with them, and they seek out situations in which they feel confident of success. He later reasoned that self-
efficacy is highly context-dependent, affecting one’s choice of activities, the amount of effort exerted, and the level of persistence needed to overcome obstacles in difficult situations (Bandura, 1981).

A teacher's sense of efficacy has been defined as "the teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (Tschannen-Moran & Woolfolk Hoy, 1998, p. 233). Numerous studies (Allinder, 1994; Guskey, 1988; Muijs & Reynolds, 2002; Woolfolk, Rosoff, & Hoy, 1990) have focused on the ways in which teacher self-efficacy predicts: (a) teachers’ goals and aspirations, (b) teachers’ attitudes toward innovation, change and evaluation, and (c) teachers’ use of teaching strategies and teacher effort.

Guskey (1987) investigated the relationship between teachers’ efficacy and affect, specifically regarding teachers’ perceptions and attitudes toward the implementation of new instructional practices. Following a 1-day staff development program on mastery learning of instructional strategies, elementary and secondary school teachers ($n = 120$) completed a questionnaire of 30 alternative-weighted items known as the Responsibility for Student Achievement (RSA) scale which measured teacher efficacy by “examining the teachers’ own beliefs responsible for influencing the successes and failures of their students” (Guskey, 1987, p. 6). The results showed significant relationships between teachers’ efficacy, affect, and teachers’ attitudes regarding the importance of practices recommended during the workshop (Guskey, 1987). More efficacious teachers as appeared to rate mastery learning as more important ($r = .42$) and similar to their usual teaching practices ($r = .36$). These teachers also rated the practices as well as being easier to implement ($r = .33$) than their less efficacious colleagues (Guskey, 1987).
Allinder (1994) investigated the relationship between self-efficacy, instructional variables, and student achievement. Allinder’s sample consisted of special education teachers \((n = 113)\) from each of four mid-western states who provided services to students with mild disabilities either directly in resource rooms or indirectly in general education classrooms. Using teacher variables identified by Rosenshine (1971) that positively correlated with increased student achievement, Allinder chose to study “enthusiasm, organization, variation in materials and activities, business-like orientation in dealing with students, and high levels of clarity” (Allinder, 1994, p. 87). Allinder (1994) defined *Personal Efficacy* as the belief that “teachers’ feelings can affect change in students” and *Teaching Efficacy* as the belief that “children benefit from schooling despite home or environmental situations” (p. 89). Participants completed a demographic questionnaire that collected total years of teaching, total years of teaching special education, years in current position, gender, and highest education degree. One-way ANOVAs and chi-square analyses explored differences between direct and indirect service providers and found no differences between the groups with respect to the demographic criteria listed above. In an extension of previous work, Allinder’s (2010) study found that *Personal Efficacy* was significantly related to three instructional components: (a) innovative teaching methods \((r = .34, p < .001)\), (b) an organized approach to instructional methods \((r = .37, p < .001)\), and (c) assuredness or confidence and enthusiasm for the craft \((r = .31, p < .001)\). The researcher also found that *Teaching Efficacy* was related to assuredness \((r = .31, p < .001)\) (Allinder, 2010).

**Science self-efficacy.** Bandura (1981) defined self-efficacy as a situation-specific construct. Riggs and Enochs (1990) and Enochs and Riggs (1990) discussed this specificity in terms of the need for teachers to demonstrate self-efficacy for science instruction. Enochs
and Riggs (1990) presented earlier research (Schoenberger & Russell, 1988; Weiss, 1978) which found that teachers often felt inadequate about science teaching. Enochs and Riggs (1990) concluded that, if a teacher demonstrates low self-efficacy in a content area, this content area would receive less time during the instructional portion of the day. With this information, Enochs and Riggs (1990) noted the importance of clarifying how understanding teachers’ self-efficacy in science instruction can shed light on understanding science teaching behaviors.

Numerous studies regarding science self-efficacy (Bleicher, 2006; Cunningham & Blakenship, 1979; Parker & Guarino, 2001; Plourde, 2002; Stevens & Wenner, 1996) have focused on understanding science self-efficacy in terms of the pre-service elementary school teacher who has yet to manage student science learning in a professional setting. In most of these studies, teacher education programs provided pre-service teachers with initial training opportunities (such as new courses or on-site programs prior to their actual teaching positions), and pre-service teachers were then surveyed to see what changes the new teachers experienced in their beliefs about science teaching.

Riggs and Enochs (1990) have identified and explored two factors related to instructional self-efficacy in science: personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). Riggs (1988) first introduced research that was later developed by Riggs and Enochs (1990) on the Science Teaching Efficacy Belief Instrument (STEBI-A), a survey instrument used to measure the science teaching self-efficacy and outcome expectancy in practicing elementary teachers (Riggs & Enochs, 1990). Later that same year, Enochs and Riggs (1990) introduced the validity and reliability research for the STEBI-B, modified from the STEBI-A and specifically designed for practicing teachers.
Enochs, Scharmann, and Riggs (1995) utilized the STEBI-B to examine 73 pre-service elementary school science teachers to better define the construct of self-efficacy in science teaching. They found significant correlations between science teaching self-efficacy and the number of science courses taken, the type of instructional practice, and participants’ perceived effectiveness of their own ability to teach science. Cannon and Scharmann (1996) also utilized the STEBI-B and found that cooperative field experiences increased pre-service science teaching self-efficacy.

Plourde (2002) used the STEBI-B to examine the impact of a student teaching semester on pre-service elementary teachers' personal efficacy and outcome expectancy in science teaching beliefs. Plourde’s study (2002) followed three cohorts of student teachers \((n = 59)\) from the end of their third semester in a large university in the western United States through their student teaching semester. These student teachers were enrolled in a science methods class, designed with standards and constructivist pedagogy that included field experience and teaching science lessons in an elementary-school setting. Students’ science teaching efficacy beliefs were examined through a pretest-posttest one-group research design, immediately prior to and directly following the student teaching semester. All 59 participants completed both the pretest STEBI-B at the beginning of their student teaching semester and the posttest STEBI-B following their student teaching. The mean scores on the STEBI-B for Personal Science Teaching Efficacy changed from 49.29 (range 30 – 64) to 50.15 (range 30 – 63), an increase of 0.86, indicating no significant difference for Personal Science Teaching Efficacy \((t (116) = 0.56, p > .05)\) between the pretest (before student teaching) and the posttest (after student teaching). However, the mean scores on the STEBI-B for Science Teaching Outcome Expectancy changed from 36.14 (range 29 - 48) to 33.93.
(range 26 – 48), a decrease of 2.21. There was a significant difference between the pretest and posttest means on the Science Teaching Outcomes Expectancy scale ($t (116) = 2.30, p < .05$) (Plourde, 2002).

These results indicated that only teachers’ outcome beliefs changed, and they decreased significantly ($p < .05$); self-efficacy beliefs did not change significantly, but there were significant negative changes for outcome expectancies suggesting that during the students’ teaching semester, specific influences eroded the confidence of these students. He identified these influences as: (a) a lack of sufficient instructional time, (b) insufficient materials and supplies, (c) inadequate collegial support, (d) unstructured curriculum and resources, and (e) the concern of classroom management (Plourde, 2002). Plourde also noted that these influences were also reported by in-service teachers as a few of the influences leading to inadequate science teaching (2002).

Limited research exists on the manner in which in-service elementary school classroom teachers who teach science both develop and maintain science self-efficacy throughout their professional careers. Researchers such as Yager (2000) have found that elementary school teachers are generally responsible for all subject areas and are not content specialists. Teaching different subject domains of the curriculum is a unique challenge for these teachers, unlike their peers in middle and secondary schools. Some teachers may feel self-efficacious when teaching language arts content skills, but they may lack efficacy when a student asks for explanations regarding scientific processes, such as the workings of a fulcrum or lever (Armor et al., 1976; Harlen et al., 1995; Enochs & Riggs, 1990; Enochs et al., 1995). By developing science self-efficacy, elementary school teachers may be
empowered to gain the necessary skills to competently present all elements of the elementary school curriculum with greater ease.

In conclusion, self-efficacy is malleable, or in other words, pliable (Palmer, 2006), and it influences teachers’ behaviors in the classroom. Indeed, Bandura’s self-efficacy research (1982) suggested that generalization and resilience were important processes in the development of self-efficacy. If teachers are expected to act as agents of change (Duschl, 1990) and increase the science achievements of young students, self-efficacy and its associated constructs must be understood in the domain of science instruction.

Factors Related to Self-Efficacy that Influence K-5th Grade Elementary School Classroom Science Instruction

The researcher searched the terms science education, science inquiry, self-efficacy and science instruction in the EBSCO database to examine factors related to higher self-efficacy for primarily pre-service teachers, as empirical research related to in-service teachers was limited. The search was limited to the previous 15 years, unless the literature was deemed seminal. The following factors were revealed and are explored in the following sections: (a) gender (George, 2006; Halpern et al., 2007; Reis & Graham, 2005; Riggs, 1991), (b) number of elective undergraduate science courses (Davis & Smithey, 2009; Eshach, 2003; Kumar & Morris, 2005’ Stevens & Wenner, 1998; Watters & Ginns, 2000), (c) number of years teaching classroom science (Ghaith & Yaghi, 1997; Guskey, 1987; Klassen & Chiu, 2010; Ross, Cousins & Gadella, 1996; Tschannen-Moran & Woolfolk-Hoy, 2007; Tschannen-Moran et al., 1998; Woolfolk Hoy & Burke-Spero, 2005), and (d) grade level taught, highest degree earned, science degree earned (yes or no) (Ferguson & Ladd,
According to researchers (Halpern, 2000; Halpern et al., 2007; Riggs, 1991), the gender gap in science education cannot be simply stated as men are better at science than women. The situation is more complex and has been studied by researchers in a number of ways that have focused on the differences between males and females and the ways in which they experience science and assimilate facts and concepts. For example, early research addressing the gender gap between the academic performance of males and females in science and mathematics had attributed these gender differences to inherent abilities (Benbow & Stanley, 1980; Gray, 1981). However, researchers have refuted the overall biological differences between men and women in science (Hyde, Fennema, & Lamon, 1990; Linn & Hyde, 1989).

There do appear to be differences between boys and girls in terms of scientific knowledge. Beller and Gafni (1996) examined the standardized test performance of 9- and 13-year old boys and girls, using the second International Assessment of Educational Progress (IAEP). A random sample of 3,300 students from 110 different schools was selected from different nations. For the purposes of the current study, only the findings from the science assessment are reported. The researchers reported that boys outperformed girls in all of the participating countries, with the gender gap larger for 13-year old students ($ES = 0.30$ for 13-year olds and $ES = 0.17$ for 9-year olds). These differences were smaller in life-sciences knowledge ($ES = 0.13$ and $ES = 0.29$ at ages 9 and 13, respectively, averaged over
all countries) and somewhat larger for physical sciences ($ES = 0.28$ and $ES = 0.42$ for ages 9 and 13, respectively) (Beller & Gafni, 1996).

Gender differences also exist regarding the types of science courses taken in middle and high school. The National Science Foundation (2005) reported on the results of Advanced Placement courses in mathematics and science. As the current study is focused on science, only the findings regarding Advanced Placement science courses are discussed. Of those students who reportedly took advanced courses, girls (40.8%) were more likely than boys (33.8%) to take advanced biology courses, Advanced Placement Biology (5.8% of girls vs. 5.0% of boys), and chemistry (59.2% of girls vs. 53.3% of boys). Boys, however, were more likely to take Advanced Placement Chemistry (3.3% of boys vs. 2.6% of all females) and physics (31.0% of boys vs. 26.6% of girls), and boys are twice as likely to take Advanced Placement Physics (2.3% of boys vs. 1.2% of girls).

Miller, Blessing, and Schwartz (2006) found that gender differences in science attitudes persist and tend to increase through the high school years. The authors used qualitative research questionnaires to examine 79 high-school students' attitudes towards science classes, perceptions of science and scientists, and views about majoring in science. Female participants who planned to major in science appeared more interested than male participants in the people-oriented aspects of the profession, and biology was the exception to females' overall low interest in science.

George (2006) also conducted research on student science attitudes by surveying 444 students from the Longitudinal Study of American Youth (LSAY), a national longitudinal study of middle school and high school students funded by the National Science Foundation. Specifically, he examined the change in students’ attitudes toward science and attitudes about
the utility of science over time. The variables were classified into the following categories: background variables, parent variables, teacher variables, peer variables, psychological and cognitive variables, attitude variables, and science activities. George (2006) reported that there was a statistically significant correlation \( r = 0.424, p < .05 \) between students’ initial attitudes toward science and their initial attitudes about the utility of science. Results also indicated that Science Self-concept variables were related to positive growth over time in the remaining variables. The correlations between variables were statistically significant \( (p < .05) \) and ranged from 0.311 to 0.583. Since the correlations were all positive, participants with higher Science Self-concept possessed more positive attitudes toward science as well as a positive view of the utility of science. George (2006) also found that, during the early elementary-school years, gender differences in attitudes toward science became evident, as girls tended to display more negative science attitudes than boys. The results demonstrated that the overall positive trend for students’ attitudes regarding the utility of science (the usefulness or value of science) declined throughout the middle school and high school years.

Seminal research (Eccles, 1989) has also explored the influence of teachers, parents and home environments on boys’ and girls’ mathematics and science attitudes. Eccles (1989) highlighted the importance of considering how students’ choices about what to study are supported by their social relationships. Adults, including teachers, advisors, and parents, were viewed as central influences. Eccles suggested that academic choices are affected by adults “who both act out and believe in traditional gender-role prescriptions regarding appropriate activities for males and females” (1989, p. 54). In her later work, Understanding Women’s Educational and Occupational Choices (1994), Eccles discussed her 15 years of gender research and applied her Model of Achievement-Related Choices to the role of
parents and teachers. Past research (Eccles, Jacobs, & Harold, 1990; Jacobs, 1991; Jacobs & Eccles, 1992) examined the role that parents have on their children when the parents have more traditional stereotypical gender views. When asked to rate their children’s’ talents in more male-typed activities like sports or physics, parents with these values tended to “underestimate their daughters’ talent and overestimate their sons’ talent” (Eccles, 1994, p. 604). Eccles warned that these gendered statements may weaken girls’ self-efficacy in these more traditionally male-dominated disciplines such as science (1994).

Studies of science and mathematics teachers have found that many were more likely to encourage boys to ask questions and to explain concepts (American Association of University Women, 1995; Kelly, 1988). In a 1981 study by Becker, teachers in high-school geometry classrooms directed 61% of their praise comments and 55% of their high-level open questions to boys. Kelly (1988) conducted a meta-analysis of 81 studies on gender differences in teacher-pupil interactions and noted that teachers spent 44% of their time with girls and 56% with boys, which translated to 1,800 more hours with boys over a child’s school career of 15,000 hours.

Teacher gender may also have a significant effect on science teachers’ attitudes and how science is taught. For example, in an early study (Taiwo, 1980), researchers found that male teachers demonstrated a significantly more positive attitude toward science teaching than female teachers ($p < .01$). Riggs (1991) also examined gender and its effect on elementary school teachers’ attitudes towards science teaching. Riggs used the Personal Science Teaching Efficacy (PTSE) scale and the Science Teaching Outcome Expectancy (STOE) scale of the STEBI-A (in-service teachers version) (Riggs & Enochs, 1990), as well as the STEBI –B (Enochs & Riggs, 1990), pre-service teachers version, to test her hypothesis
that both pre- and in-service female teachers would demonstrate lower science teaching self-efficacy beliefs than male teachers. Riggs’ sample consisted of 331 in-service teachers from both rural and urban school districts and 210 rural and urban pre-service teachers. She found that male teachers in both the pre- and in-service groups \((M = 58.90\) and \(M = 50.19\), respectively) scored significantly higher \((p < .05)\) on self-efficacy than female teachers in both the pre- and the in-service groups \((M = 55.48\) and \(M = 46.51\), respectively) (Riggs, 1991). However, there were no significant differences on outcome expectancies between males or females in either the pre-service or in-service groups; however, the in-service group of teachers reported higher outcome expectancy scores when compared to the pre-service group. Riggs noted that “although the female teachers reported less belief in their own abilities, they were as positive as males that good teaching would result in student learning” (Riggs, 1991, p. 8).

In conclusion, previous research (Bleeker & Jacobs, 2004; Eccles, 1989; Halpern et al., 2007) demonstrated that a gender discrepancy in science does exist from the domains that interest boys and girls, to home experiences and science education in classroom settings. This research study attempted to understand this particular aspect as it related to self-efficacy and classroom instruction that promotes effective science learning for all students, both girls and boys.

**Number of Elective Undergraduate Science Courses**

Little research exists on which courses *in-service* teachers recall as being influential when looking back over their undergraduate training. However, a considerable amount of research (Bleicher, 2006; Czerniak & Shriver, 1994; Enochs & Riggs, 1990; Finson, Riggs, & Jesunathadas, 1999; Haefner & Zembal-Saul, 2004; Hoy & Woolfolk, 1990; Morrell &
Carroll, 2003; Moseley, Reinke, & Bookout, 2003; Palmer, 2006; Parker & Guarino, 2001; Watters & Ginns, 2000) has focused on the impact various forms of undergraduate coursework, field experiences and training opportunities may have on science self-efficacy and teaching attitudes for pre-service teachers before these teachers are assigned to classrooms.

The reason for this is two-fold. Pre-service teachers often doubt their ability to teach science effectively in classroom settings (Stevens & Wenner, 1996) based on the beliefs and attitudes they have developed as a result of their own science related experiences in elementary and high schools (deLaat & Watters, 1995; Watters & Ginns, 1995). Some researchers have found that pre-service teachers who demonstrate higher science self-efficacy make better progress as beginning science teachers (Appleton & Kindt, 2002) and can be expected to utilize high-quality, inquiry-based teaching methods once in a classroom setting. However, these longitudinal studies are few in number, and follow participants for a relatively short period of time into their teaching careers.

Kumar and Morris (2005) conducted a multiple regression analysis of undergraduate elementary science students (n = 176) which examined the relationship between prospective teachers’ scientific understanding and gender, education level (high school, college), courses in science (biology, chemistry, physics, earth science, astronomy, and agriculture), and science and mathematics attitudes. The undergraduate elementary-school science methods course students in an urban doctoral-level university voluntarily took the Scientific Understanding Survey developed by Klapper et al. in 1993. The survey was designed to uncover basic understandings in biology, chemistry, earth, astronomy, and physics, mathematics skills used in science, as well as some demographic information and open-ended survey items that examined science and mathematics attitudes. The alpha reliability
of the instrument was 0.68 (Kumar & Morris, 2005). The regression model results indicated that gender, college level chemistry ($r = 0.29$) and physics ($r = 0.34$) were significant predictors ($p < 0.007$) of these students’ understandings of scientific principles. A multiple regression using all significant bivariate predictors (Gender, HS Chemistry, HS Physics, College Chemistry, College Physics, Attitude Towards Science, Attitude Towards Math) was also significant, $R^2 = 0.26$, $F(7, 162) = 8.12$, $p < 0.001$ (Kumar & Morris, 2005). In the discussion of their findings, Kumar and Morris (2005) referred to Shulman’s (1986) PCK research, which stressed that both the content and methods of teaching require specialized curricular knowledge and pedagogical training for optimal instruction.

Recent longitudinal research (Davis & Smithey, 2009) conducted with new teachers has identified gaps in the literature on how beginning teachers deal with expanding elementary science standards, science inquiry, and the use of curricular materials. Davis and Smithey (2009) interviewed 25 pre-service teachers throughout the course of 10 years and used design-based research to inform their teaching. They followed individual teachers through their pre-service methods classes into their first few years of teaching, utilizing written student work, transcripts of teacher interviews, and qualitative content analysis using some emergent themes from the related literature. The authors identified three important problems of practice shared by pre-service teachers and teacher educators: “(a) engaging students, (b) organizing instruction; and (c) understanding students” (Davis & Smithey, 2009, p. 746). The authors argued that overcoming these challenges could best be accomplished by focusing on these three goals as part of undergraduate methods programs: “(a) learning about inquiry-oriented science teaching, (b) using science curriculum materials effectively, and (c)
anticipating and working with students’ ideas in instruction” (Davis & Smithey, 2009, p. 746).

In another study, researchers (Watters & Ginns, 2000) investigated the perceptions of 161 elementary pre-service teachers enrolled in the third year of a 4-year Bachelor of Education program. They participated in a science education methods course, based on Morrisey’s (1981) research, which suggests that teachers who teach science are influenced by their own science knowledge, issues in science teaching, and their feelings or attitudes about those issues. The methods course investigated a range of topics, including the nature of science, constructivism, and more. All classes included content from the conceptual areas of energy, matter, earth and weather, life science, and space.

Researchers obtained: (a) quantitative data through the use of the Personal Science Teaching Efficacy scale (PSTE) and Science Teaching Outcome Expectancy scale (STOE) of the STEBI-B; and (b) qualitative data gathered through surveys, observations and focus groups (Waters & Ginns, 2000). Results indicated that students exhibited significant gains in self-efficacy ($p = .008, d = .64$, large) as a result of the methods course. The stability of the outcome expectancy scores was consistent with the authors’ view that students “were less optimistic about the outcomes of science teaching, attributing external factors as potential inhibitors of effective teaching” (Waters & Ginns, 2000, pp. 8-9). Students in the focus groups reported that assignments based on problem–based learning that featured collaborative learning and reflective journal writing were most beneficial, acknowledging that “the metacognitive value of the journal… helped them to understand [science] course content. (Waters & Ginns, 2000, p.12)
In their qualitative results, Watters and Ginns (2000) reported that students in the focus groups discussed their experiences in both the Science Foundation course (taken in first year) and a Science Education course (taken in the third year) required of all students in the pre-service program. The Science Education course was reported as being more useful in “developing understanding and confidence” (Watters and Ginns, 2000, p. 9). Barbara (pseudonym) noted that: “[the] Science Education [course] sort of cleared everything of that [high school science] up for me” (p.10) and Catherine (pseudonym) noted that:

I think my confidence has grown. I think I’ve learnt more about science itself, science experiments, and just a little bit on how to explain science. I probably need more interactions with children to actually build my confidence more with actually teaching it. (p. 10)

Haim Eshach (2003) further investigated in-service educators’ concerns by conducting research with practicing teachers from 20 developing nations throughout Asia, Africa, Eastern Europe and the Caribbean Islands. He used the STEBI-A to examine changes in in-service educators’ self-efficacy and attitudes resulting from two 4-day workshops based on the Inquiry Events (IE) teaching method (Eshach, 2003). The IE teaching method involves “dealing with open-ended problems taken from a real-life situation, encouraging investigation of different kind of issues-ethical, economic, aesthetic, etc.” (Eshach, 2003, p. 486). Two groups of participants ($n = 58$) included kindergarten through second grade teachers, curriculum developers and teacher-trainers. The results of the $t$-paired sample tests indicated that there was a significant difference ($p < .05$) in the scores for posttest Personal Science Teaching Efficacy Belief ($M = 3.94$, $SD = 0.37$) and pretest Personal Science Teaching Efficacy Belief ($M = 3.45$, $SD = 0.378$) and posttest Science Teaching Outcome
Expectancy \((M = 4.45, \ SD = 0.19)\) and pretest Science Teaching Outcome Expectancy \((M = 3.95, \ SD = 0.13)\) (Eshach, 2003). In the posttest questionnaire, participants reported that the IE workshop model: “(a) presented science as an integral part of life; (b) helped to teach science effectively; (c) contributed to the development of the child’s cognitive skills; and (d) helped the child develop social skills” (Eshach, 2003, p. 499).

To conclude, colleges and universities are faced with the dilemma of how many and which undergraduate science content and education courses to offer pre-service teachers, and how to modify courses to enhance students’ scientific understanding. More content is necessary, but simply increasing the number of traditional science course offerings to education students as part of either pre-service or in-service teacher preparation programs may not always be the most appropriate way to train competent elementary school science teachers (Eshach, 2003). If the goal for improved science instruction is to provide teachers with inquiry-based science teaching methods that feature constructivist methods of observation, questioning and thinking as suggested by the NRC (2000) and the NSTA (2011), then pre-service and in-service teachers will benefit from learning experiences that feature these methods.

**Number of Years Teaching Classroom Science**

A literature review on the effects of classroom experience on practicing teachers’ science self-efficacy yielded limited information. In fact, little is known about how teachers’ self-efficacy in general is related to years of experience (Klassen & Chiu, 2010). In the challenging early stages of a teacher’s career, it is believed that their self-efficacy is precarious, but that with time and experience, it may increase and become more established.
(Tschannen-Moran & Woolfolk Hoy, 2007). However, few studies have examined in-service teachers’ self-efficacy during the middle or later stages of their careers.

Ross et al. (1996) and Ghaith and Yaghi (1997) found negative correlations between years of experience and teacher self-efficacy. A longitudinal study conducted by Woolfolk Hoy and Burke-Spero (2005) contained teacher data collected at two points in time: once during participants’ teacher-training programs and again at the end of their first year of teaching. Results demonstrated that beginning teachers’ self-efficacy significantly increased during teacher training, followed by a decline that continued through the end of their first year of teaching (Woolfolk Hoy & Burke-Spero, 2005).

Tschannen-Moran et al. (1998) noted that teachers’ self-efficacy is built upon the combination of: (a) successful past experiences, (b) principals’, students’, peers’, and parents’ verbal support, and (c) opportunities for observation of successful peers. Bandura (1997) noted that some mid-to-late career stage workers may choose to slow down and re-evaluate their goals due to waning self-efficacy. He also noted that some working environments help to encourage (and discourage) the workers’ self-efficacy development (Bandura, 1997). Therefore, it is safe to conclude that a variety of personal and environmental factors influence a teachers’ lifelong self-efficacy for teaching.

Klassen and Chiu (2010) found that the relationship between teachers’ self-efficacy and experience may not be a linear one. They examined the relationships among teachers’ years of experience, teacher characteristics (gender and teaching level) and three domains of self-efficacy (instructional strategies, classroom management, and student engagement). They also investigated two types of job stress (workload and classroom stress) and job satisfaction. Their sample of convenience (n =1,430) practicing teachers (69% women, 31%
men) attended an annual, mandatory Canadian teacher conference of approximately 8,000 teachers from about 350 schools. Individual participants were asked to complete a brief questionnaire titled *What Motivates Teachers?* The survey included: (a) an information sheet and consent form, (b) a demographics section, and (c) four additional measures consisting of a teachers’ self-efficacy scale, a job satisfaction scale, an item measuring overall job stress, and seven items measuring sources of job stress. The *Teachers’ Self-Efficacy Scale* (TSES) (Tschannen-Moran & Woolfolk-Hoy, 2001), containing 12 items with a 9–point response scale ranging from 1 (nothing) to 9 (a great deal), was used to measure teachers’ self-efficacy.

Klassen and Chiu (2010) used factor analysis, item response modeling, systems of equations, and a structural equation model for data analysis. They found that teachers’ self-efficacy for instructional strategies and classroom management increased as job satisfaction increased, whereas overall job stress was associated with lower job satisfaction. Klassen and Chiu (2010) reported that teachers’ self-efficacy was “influenced by years of experience in a nonlinear relationship, with…teacher efficacy increasing with experience for early and mid-career stage teachers and declining for teachers in the late career stages” (2010, p. 747). The authors suggested that teachers gain teaching skill confidence during their early years of teaching and into the mid-career years, but that these confidence levels may decline as teachers enter the later career stages.

Other research suggests mixed results. For example, Tschannen-Moran and Woolfolk-Hoy (2007) found that teachers’ self-efficacy increased with experience, but Guskey (1987) found that it did not. Therefore, no body of research supports a consistent
view that in all cases, teachers’ self-efficacy increases with additional years teaching in the classroom.

**Grade Level Taught, Science Degree, and Highest Degree Earned**

The literature review revealed limited research on the topic of whether specific grade levels are associated with increased or decreased self-efficacy in practicing science teachers. One study conducted by Marshall et al. (2009) utilized survey methodology to explore the perceptions regarding inquiry in the classroom of 1,222 K-12 mathematics and science teachers from a large school district in the southeastern United States. Researchers examined grade level taught, content area taught, level of support received, and self-efficacy for teaching inquiry to determine whether these items were significantly correlated with teachers’ beliefs and practices. Specifically, a one-way ANOVA was used to evaluate the relationship between teachers’ grade level and their self-reported behaviors related to inquiry instruction. Findings indicated that “elementary science teachers report using inquiry to a greater extent [than the middle and secondary teachers reported] and [many of the elementary science teachers] believe a greater percentage of time should be devoted to inquiry than elementary mathematics teachers do” (Marshall et al., 2009, p. 593). In their discussion of the findings, the authors concluded that more research is needed before generalizations can be made about inquiry instructional trends across grade levels (Marshall et al., 2009).

A literature review of teacher degrees and subject area certifications was generally tied to student achievement, with many of the key studies taking place in the 1980s and 1990s (e.g., Ferguson & Ladd, 1996). Studies in science are limited, but limited studies in other domains do exist; these studies often contradicted each other, and yet, their findings are relevant to this study. At the high school level, a clearer picture has begun to emerge
regarding the effect of teacher degrees and certification. However, the elementary school level evidence remains mixed and inconclusive.

For example, a widely cited Alabama study of 30,000 primary school teachers conducted by Ferguson and Ladd (1996) found a positive correlation between students’ learning gains in reading and teachers’ scores on their own high school ACTs. The one standard deviation difference in a teacher’s ACT score generated a .1 standard deviation difference in fourth grade students’ reading scores. However, there was no significant correlation between teachers’ ACT scores and students’ math achievement.

In a second study, Rowan et al. (2002) found that teachers earning master’s degrees produced no discernable effect on elementary-school students’ achievement. However, Rowan et al. (1997) found that secondary school mathematics teachers’ knowledge did have a positive impact on student knowledge, although the result of a single math question in the study was used as the indicator of math skills.

Goldhaber and Brewer (1997b, 1998) used the data from The National Education Longitudinal Study of 1988 (NELS: 88), a nationally representative sample of eighth graders who were first surveyed in the spring of 1988, to further confirm the importance of subject-specific information about teacher preparation. A sample of these respondents was re-surveyed through four follow-ups in 1990, 1992, 1994, and 2000. These respondents reported on a range of topics, including teachers’ degrees and levels and levels of student achievement. Their findings suggested that levels of teachers’ degrees were not related to high school student achievement in math, science, English, or history. However, in math and science, teacher-earned subject-specific degrees were found to have a positive impact on students’ test scores; this finding held for teachers holding either BA/BS or MA/MS degrees.
Further, the most effective teachers held both a bachelor’s and a master’s degree in the same subject area.

In his monograph that explored the possible influence of classroom practices on student achievement, Wenglinsky’s (2000) qualitative study analyzed data from the National Assessment of Educational Progress (NAEP), referred to as the Nation’s Report Card, administered annually to U.S. students in a variety of subjects. In addition to standardized tests consistent with high academic standards, the NAEP database includes questionnaires sent to students, their teachers, and their principals. Wenglinsky (2000) analyzed the data collected from the 1996 NAEP mathematics assessment \( (n = 7,146 \text{ eighth graders}) \) from the 1996 NAEP science assessment \( (n = 7,776 \text{ eighth graders}) \). Both databases included students’ scores on the assessments, background information about the students (such as their socioeconomic status) drawn from the student questionnaires, and information on teacher inputs, professional development, and classroom practices, as well as other school information (such as class size) drawn from the teacher questionnaires.

Among other findings, the study linked classroom practices, professional development experiences, and teacher inputs to student academic performance. Wenglinsky (2000) reported that students’ achievement in science and mathematics increased when their teachers earned a major or minor concentration in the subject matter. Specifically, students whose teachers either majored or minored in the subject they were teaching outperformed their peers by almost half of a grade level in both math and science. Also, students whose teachers received professional development in higher order thinking skills or laboratory skills outperformed their peers by almost half of a grade level. And finally, students whose
teachers conducted hands-on learning activities outperformed their peers by almost three-fourths of a grade level in math and almost half a grade level in science (Wenglinsky, 2000).

**Conclusion**

Young elementary children bring with them an incredible amount of curiosity about the world around them. Teaching science to these students can satisfy their search for answers about the world they are beginning to understand, and encourage and hopefully maintain their interest in the field of science as they mature (Eschach & Fried, 2005). In the first part of this literature review, the focus was on the need for more inquiry-based reform, through the efforts of national organizations, colleges and universities and innovative programs that center on national science standards, teacher training and support, better allocation of resources and program delivery. Further on, a more in depth understanding of teacher behavior and teacher knowledge associated with science self-efficacy was presented. A brief history of the behavioral theorists and their contributions to such constructs as attitude, beliefs, achievement and motivation offered a deeper understanding of the complexity and acquisition of self-efficacy. This part of the review concluded with current research that is defining more effective inquiry-based classroom practices in science education, including the importance of questioning skills in developing thinking skills, a key element found in more inquiry-based science instruction.

In the second part of the review, the focus shifted to factors associated with science self-efficacy. Gender of teachers and students, the number, quality and variety of elective undergraduate science courses a teacher has taken, experience teaching classroom science, the grade level taught, whether or not a teacher has a science degree, and the highest degree earned by teachers were the factors explored. By understanding the relationships that
surround these factors, together with a deeper theoretical understanding of the manner in which teachers develop science self-efficacy, this study contributes to the existing research as it relates to improving science classroom instruction.
CHAPTER THREE: METHODOLOGY

This chapter provides the research questions and hypotheses, the research design, a description of the setting and the participants, instruments and their reliability and validity, and data collection procedures used in the current study. The timeline for this research completes this chapter.

Research Questions and Hypotheses

The following questions were addressed in this study:

1. To what extent and in what manner do the internal factor (gender) and external factors (grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, science degree-yes or no) predict self-efficacy in science teaching for practicing elementary-school teachers who teach science in grades K-5?

2. To what extent and in what manner does self-efficacy predict the (self-reported) occurrence of higher order questions for practicing classroom teachers who teach science in grades K-5?

3. How do practicing elementary school teachers view the importance of questioning skills in science instruction?

4. What instructional methods do practicing teachers in grades K-5 prefer to use when they teach elementary school science? Why?

The researcher tested the following hypotheses for the quantitative research questions one and two:

1. The internal factor (gender) and external factors (grade level taught, years of experience, highest degree earned, number of elective undergraduate science...
courses, science degree-yes or no) will predict self-efficacy in science teaching for practicing elementary school teachers who teach science in grades K-5.

2. Self-efficacy will predict the (self-reported) occurrence of higher order questions for practicing classroom teachers who teach science in grades K-5.

**Research Design**

This study employed survey methodology in a convergent parallel mixed method research design. A central premise of mixed methods research is that “the use of quantitative and qualitative approaches, in combination, provides a better understanding of research problems than either approach alone” (Creswell & Clark, 2011, p. 5). A quantitative research design was most appropriate for research questions one and two. Gall et al. (2007) noted that a quantitative research design allows researchers to “view causal relationships among social phenomena, and use statistical inference procedures to generalize findings from a sample to a defined population” (p. 32).

Specifically, a quantitative correlational research design allowed the researcher to address research questions one and two. Correlational designs are useful in exploring issues in the social sciences, as they allow the researcher to investigate relationships among and between a large number of variables in a single study, or the degree of the relationship between the variables (Gall et al., 2007).

For research questions three and four, a general qualitative research design was most appropriate to analyze participants’ responses from open-ended survey items. Qualitative research designs may be used to “develop a deeper understanding of the phenomena being studied” (Gall et al., 2007, p. 178). According to Dillman, Smyth, and Christian (2009), “the strength of open-ended question format is that it allows respondents to freely answer the
question as they want without limiting their response” (p. 72). In qualitative research, the focus is not on reliability as much as trustworthiness to establish the credibility and accuracy of the participants (Lincoln & Guba, 1985).

One of the strategies used to establish validity in a mixed methods study is the triangulation of data from various sources (Creswell & Plano-Clark, 2011). Open-ended items were included in the CSIS survey for the purpose of elaborating and further exploring the quantitative results. Both the quantitative and qualitative data were collected at the same time, validated, and interpreted using a convergent parallel model as suggested by Creswell and Plano-Clark (2011).

**Description of the Setting and Participants**

**Setting**

Faculty members from eight elementary schools, a sample of convenience located in six school districts in the northeast region of the U.S. participated in the study. The six school districts spanned two states and two counties that are in close geographical proximity. Two of the districts are located in suburban cities (population of 77,062 and population of 80,893, respectively), and four of the districts are located in suburban towns (population ranged from 1,436 to 12,396) (U.S. Census Bureau, 2011). Table 2 lists the number of elementary schools located in each district, as well as the number of schools from within each district that participated in the study.
Table 2

*Sampled Schools Within the Selected Districts*

<table>
<thead>
<tr>
<th>Number of K-5 Elementary Schools in the District</th>
<th>District A</th>
<th>District B</th>
<th>District C</th>
<th>District D</th>
<th>District E</th>
<th>District F</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>12</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

| Number of K-5 Schools in the Sample from Each District | 1 | 2 | 1 | 1 | 1 | 2 | 8 |

These districts were selected as possible research sites as they spanned suburban towns and cities, and they were also representative of a wider socioeconomic population, demonstrated by the varied student demographics and by the free and reduced lunch statistics reported for each district (Table 3). Note that in District E, the elementary schools offer kindergarten through grade 4 only in their particular district. District A served a greater number of non-White students (69%) and a fewer number of White students (31%) when compared to the other districts. Also, sampled schools in District A served fewer non-White students than in the overall district (56% and 23% compared to 69% overall for the district), and fewer students eligible for free and reduced lunch. Also, sampled school 2 in District F had a greater number of students (50%) eligible for free and reduced lunch as compared to the district’s average (29.4%). In addition, District F served almost as many non-white students (49.9%) as white students (50%).
<table>
<thead>
<tr>
<th>District and Sampled School(s)</th>
<th>Number of K-5 Students</th>
<th>Percentage of Students Eligible for Free and Reduced Lunch</th>
<th>Percentage White</th>
<th>Percentage Non-White</th>
</tr>
</thead>
<tbody>
<tr>
<td>District A</td>
<td>3,762</td>
<td>42.0</td>
<td>31.0</td>
<td>69.0</td>
</tr>
<tr>
<td>School</td>
<td>1,020</td>
<td>30.0</td>
<td>44.0</td>
<td>56.0</td>
</tr>
<tr>
<td>District B</td>
<td>1,351</td>
<td>5.0</td>
<td>77.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Schools 1 and 2</td>
<td>616</td>
<td>School 1: 2.0</td>
<td>School 2: 0.0</td>
<td>87.0</td>
</tr>
<tr>
<td>District C</td>
<td>2,180</td>
<td>0.0</td>
<td>78.0</td>
<td>22.0</td>
</tr>
<tr>
<td>School 1</td>
<td>444</td>
<td>0.0</td>
<td>80.0</td>
<td>21.0</td>
</tr>
<tr>
<td>District D</td>
<td>1,177</td>
<td>15.0</td>
<td>78.0</td>
<td>21.0</td>
</tr>
<tr>
<td>School 1</td>
<td>363</td>
<td>9.0</td>
<td>75.0</td>
<td>30.0</td>
</tr>
<tr>
<td>District E</td>
<td>1,552</td>
<td>1.0</td>
<td>86.0</td>
<td>16.0</td>
</tr>
<tr>
<td>School 1 (K-4 only)</td>
<td>528</td>
<td>2.0</td>
<td>83.0</td>
<td>18.0</td>
</tr>
<tr>
<td>District F</td>
<td>4,322</td>
<td>29.4</td>
<td>50.0</td>
<td>49.9</td>
</tr>
<tr>
<td>Schools 1 and 2</td>
<td>721</td>
<td>School 1: 10.5</td>
<td>School 2: 50.0</td>
<td>72.8</td>
</tr>
</tbody>
</table>
The targeted sample consisted of elementary school classroom teachers who taught science in the eight sampled schools. Table 4 presents the total number of full-time K-5 teachers and the total number of classroom science teachers at the eight schools.

Table 4

*Number of Teachers and Science Teachers in Grades K-5 at the Eight Sampled Schools*

<table>
<thead>
<tr>
<th>District A Sampled School</th>
<th>District B Sampled Schools</th>
<th>District C Sampled School</th>
<th>District D Sampled School</th>
<th>District E Sampled School</th>
<th>District F Sampled Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time K-5 Teachers</td>
<td>72</td>
<td>43</td>
<td>36</td>
<td>27</td>
<td>40</td>
<td>44</td>
</tr>
<tr>
<td>K-5 Classroom Science Teachers</td>
<td>48</td>
<td>28</td>
<td>26</td>
<td>19</td>
<td>24</td>
<td>38</td>
</tr>
</tbody>
</table>

In Districts A – E, the state’s science assessment was administered to elementary school students in grade 4, and the results of these assessments are presented in Table 5. This assessment is designed to measure students’ knowledge of science content contained in the state’s elementary science curriculum and the state’s learning standards of mathematics, science and technology (elementary level).
Table 5

*Grade Four Science State Assessment Scores in Districts A-E for 2009-2010*

<table>
<thead>
<tr>
<th>District Mean Score</th>
<th>District A</th>
<th>District B</th>
<th>District C</th>
<th>District D</th>
<th>District E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampled School(s)</td>
<td>School 1 – 91 School 2 – 93</td>
<td>85</td>
<td>91</td>
<td>90</td>
<td>83</td>
</tr>
</tbody>
</table>

District F was located in another state from the remaining districts, and so the state science assessment was administered to elementary students in grade 5. In 2009-2010, overall 41.5% of District F’s elementary school students met the state’s level 4, which is considered *Goal*. In Sampled School 1, 75% of the fifth grade elementary school students met *Goal*, and in Sampled School 2, 73.6% of the fifth grade elementary school students met *Goal* (Connecticut Education Data and Research, 2011).

Each of the districts was asked to report on the frequency of science instruction either per individual school or in regards to district policy, which elicited a variety of responses, yielding a response rate of 88%. District B reported that each elementary school classroom teacher kindergarten through fifth grade is expected to provide 50 minutes of science instruction 2 times per weekly cycle (per personal telephone communication April 16, 2012). District C reported that elementary science instruction is expected to take place for a minimum of 2 hours per week (per personal telephone communication April 9, 2012). Districts D, E, and F noted that there was no prescribed amount of time allotted for science as compared to hour blocks of instructional time slated for literacy and mathematics (per
personal telephone communication April 10, 2012). District A was unresponsive to the request.

**Sample Selection and Response Rate**

The target population for the study was elementary school classroom teachers in grades kindergarten through five who were responsible for teaching elementary school science curriculum. The participants in this study were a sample of convenience selected to suit the purpose of the study. Gall et al. (2007) noted that although convenience sampling is “used in more than 95 percent of social science research, it is more difficult to make a valid inference about a population” (p.174) using non-probability sampling methods. However, it is important to recognize that convenience sampling offers the researcher easier access to participants so that the study can occur (Gall et al., 2007).

The researcher communicated with administrators by creating an email account specifically for the study. This account included telephone contact information, which became an efficient way to communicate with participating schools and individual district and school administrators. The researcher contacted districts by an initial electronic mail correspondence with an attached formal request letter tailored for each superintendent or district administrator (Appendix K). These electronic correspondences were often followed by phone contact to office assistants who helped to facilitate administrators’ responses. The district superintendent, assistant superintendents or the assistant superintendents of curriculum and instruction then provided written permission for their building principals and administrators to be contacted directly by the researcher (Appendix L).

Again, electronic mail and phone contact were made with individual principals to set up mutually agreed upon gathering times for faculty to participate in the study. At the
researcher’s suggestion, pre-scheduled faculty meetings were selected, and the research study typically took place at these meetings. Following a brief introduction by the building administrator, the researcher or the building administrator addressed the assembled faculty and provided the details of the study. If the researcher administered the study, a short introductory script was read (Appendix I). Those faculty members who were not kindergarten through fifth grade classroom teachers responsible for classroom science instruction were either excused by the principals or remained in the room but did not participate in the survey.

For those who agreed to participate, the researcher or building administrator informed the teachers of the purpose and voluntary nature of the study. Two 15 dollar gift cards to a book store were made available to the faculty participants at the schools where the researcher directly administered the study if the building administrator had granted advance approval. Dillman et al. (2009) noted that “small token incentives improve response rates…” and “participants feel that they should reciprocate for the reward they receive by completing the survey” (p. 22).

Dillman et al. (2009) also outlined social exchange theory as a method that encourages people to respond to a request for survey participation. The authors suggested that information should be provided about the study, together with a request for participation that appeals to respondents’ sense of social responsibility (Dillman et al., 2009). The building administrators assured the faculty members that this was a worthwhile study and it was approved by the district administrators. The teachers then voluntarily chose to participate, as many of them expressed a willingness to be helpful and offer their opinions to
improve science instruction. All these measures helped to ensure that participants would participate in the current research study.

According to Rea and Parker (2005), a survey’s response rate is the result of number of people who were eligible and asked to participate divided by the total number of people in the sample who actually participated; response rate is normally expressed as a percentage. Dillman (1978, 2000) encouraged response rates close to 80%, while at the same time acknowledging that such high rates are very difficult to obtain. Rea and Parker (2005) also noted that a response rate of 50% for the general public and a somewhat higher rate for specialized populations is ideal. In the current research study, of the 183 possible kindergarten through fifth grade teachers who were eligible for participation in the research study, 145 submitted completed surveys, yielding a response rate of 79.2%.
**Instrumentation**

Data were collected using survey methodology, in which data are collected from participants in the study at a specific point in time (Gall et al., 2007). The Classroom Survey Instruction Survey (CSIS) was designed using guidelines from Dillman et al.’s (2009) Tailored Designed Method, which suggests that “respondent behavior is motivated by the return that behavior is expected to bring” (p. 16). The CSIS was designed as a paper survey, and distributed to the participants with combined close-ended and open-ended item formats.

**Survey Construction**

A literature review on survey research (Couper, 2000; Dillman, 2000; Dillman, Smyth, & Christian, 2009; and Groves, 1989) revealed that specific strategies help to ensure that accurate survey information is a true reflection of individuals’ beliefs and perceptions about a particular topic. However, four types of survey error have been outlined by these survey researchers: (a) coverage error occurs when not all the members of a survey sample have an equal chance of being included in the sample; (b) sampling error occurs when the “extent to which the precision of the survey estimates is limited” (Dillman et al., 2009, p.17) because not every person in the population has been surveyed; (c) non-response error occurs when not everyone who was sampled responds to the survey; and (d) measurement error occurs when the respondent offers responses that are inaccurate.

The researcher responded to these challenges by implementing various procedures. By offering participants the ability to respond to a paper survey, coverage error was minimized. Dillman et al. (2009) have suggested that, although “internet surveys can be designed and implemented and results reported faster than any of the traditional survey modes” (p. 9), paper surveys allow the respondents to “peruse the entire questionnaire to get
a sense of topic covered and length, which may be more difficult to do on the Web” (p. 183). In addition to Dillman (2000), Smith (1997) noted that not all respondents are comfortable with either the technical aspects of on-line responses or the ethical considerations of their opinions being shared.

In order to minimize the threat of sampling errors, a random sampling is suggested (Dillman et al., 2009). However, because random sampling was difficult to achieve in the current study, a sample of convenience was gathered from local school districts within the geographic area of the researcher’s home and place of employment. The selected districts and their targeted schools were selected to represent some variety in socioeconomic status, based on their reported free and reduced lunch and demographic statistics.

Non-response error also creates concern. Couper (2000) found that “not all people included in a sample are willing or able to complete the survey” (p. 473). Dillman et al. (2009) have suggested that it is important to motivate the majority of the group to participate, so that opinions from all groups are reflected in the final responses. By personally administering the survey to as many of the faculty members at each school as possible, the researcher attempted to minimize this threat by encouraging participation in a scheduled faculty gathering such as a faculty meeting, both administering and collecting at the same occasion. This made the collection of data more streamlined and convenient for administrators and faculty alike.

When permitted by the building administrator, the researcher provided two small incentive gift cards in the amount of 15 dollars each by lottery to assembled faculty members who participated in the research. Dillman et al. (2009) noted that prize drawings and lotteries in web-based surveys “are not as effective as traditional cash incentives or material
incentives” (p. 275) as paper surveys. The faculty at only three of the sampled schools participated in the lottery, because other schools’ administrators either declined or had decided to self-administer the survey.

The final error discussed is one of measurement. Dillman et al. (2009) suggested that questionnaires are to be organized in a “logical order” (p. 157). These researchers compare the process of survey completion to an actual conversation between the survey creator and the survey respondent. By organizing the survey with the respondent in mind, the survey creator makes clear and accurate responses more likely. The CSIS was designed to be eye-appealing; the researcher used techniques such as underlining, capital letters, italics, bolding, size of text and shading to make the survey more cohesive and user-friendly. As suggested by Dillman et al. (2009), “information is presented similarly throughout the questionnaire” (p.178). In all but one administration, the CSIS survey that each teacher received was photocopied onto white paper, single-sided, and stapled in the top left-hand corner, which facilitates easy access and therefore increases participation with fewer errors due to participant confusion (Dillman et al., 2009). However, at one school, the district administrator chose to download and photocopy an electronic version of the survey; this survey was administered as a two-sided document. Unfortunately, not all the participants at this sample school ($n = 19$) signed the signature page, which rendered only 14 surveys usable.

The CSIS (Appendix A) contained four sections: (a) a set of demographic items, (b) a set of open-ended items (c) the Science Teaching Efficacy Belief Instrument (STEBI – A, Personal Science Teaching Efficacy Beliefs subscale only) (Riggs & Enochs, 1990), and (d)
the National Research Center on the Gifted and Talented (NRC/GT) Classroom Practices, Questioning and Thinking subscale only (Archambault et al., 1993).

Survey Contents

Demographics. Section One of the CSIS was titled Teacher Information (Appendix B). In survey item 1, participants were directed to check either male or female (gender). Survey item 2 directed participants to check the grade level they currently teach as kindergarten, first, second, third, fourth or fifth as well as multi-level with specific grades. Survey item 3 directed the participants to write in their years of experience teaching classroom science, as expressed by years. Survey item 4 directed the participants to check off their highest degree earned from one of the three choices: Bachelor of Arts or Science; Masters of Arts or Science; or Doctor of Philosophy or Education. Survey item 5 directed the participants to check off how many elective undergraduate science courses they had taken: the choices were none, one to two, three to four, or five or more. Survey item 6, the last question in this section, directed the participants to note if they did or did not have a science degree. All of these items were included because they provide the necessary data for the quantitative analyses.

Open-ended responses. The second section in the survey, Teacher Beliefs, listed five open ended items (Appendix C). The researcher developed open-ended items to elicit authentic reflections from individual teachers regarding their science teaching and to assist in the triangulation of quantitative data. Dillman et al. (2009) noted that open-ended items allow respondents to: (a) answer questions without being unduly influenced by the researcher, and (b) gather information on a particular topic that the researcher lacks in advance of the question. However, Dillman et al. (2009) noted that there are limitations,
such as non-item response which occurs if respondents choose not to answer open-ended questions because they require more time and effort to complete.

In these open-ended items, teacher participants were asked to: (a) review past experiences that might have influenced their classroom science instruction; (b) specify what they think good science teaching is; (c) note their beliefs regarding their own strengths; and (d) note the challenges they face as classroom science teachers.

Four lines were made available for each item for respondents to record their information, and the directions suggested that the back of the sheets may be used if more room was required. Survey item 7 stated: How do good teachers teach elementary school science well? Survey item 8 stated: Are there any experiences outside the classroom that you believe have increased your effectiveness as a classroom science teacher? Survey item 9 stated: What do you think you do well when you are teaching science? Survey item 10 stated: What are some of the challenges you face when teaching science? Survey item 11 stated: How do you encourage students’ questioning and thinking skills in your classroom?

Closed-ended responses. The Teachers’ Beliefs section continued with 13 closed-ended statements that required Likert-type scale responses. These responses were included to examine the science self-efficacy of K-5 elementary school teachers. Science self-efficacy was measured with one of the two subscales from the STEBI–A. The final section of the Teachers’ Beliefs section contained five statements that required Likert-type scale responses to examine the manner in which elementary school teachers’ science self-efficacy scores predict the frequency of high-level questioning methods in the classroom. The researcher utilized the National Research Center on the Gifted and Talented’s (NRC/GT) CPS. These two instruments are described in the following passages.
Science Teaching Efficacy Belief Survey Instrument (STEBI – A). The STEBI–A is considered to be a valid and reliable instrument when used to measure science self-efficacy in in-service (practicing) teachers (Morrell & Carroll, 2003). Two versions of the STEBI instrument were developed: (a) The STEBI-A was designed for practicing or in-service elementary school teachers (Appendix D; Riggs, 1988; Riggs & Enochs, 1990); and later that same year (b) the (STEBI-B was designed for pre-service elementary school teachers (Enochs & Riggs, 1990). The current research utilized the STEBI-A, as the study’s participants consisted of in-service teachers. The complete STEBI–A survey is composed of 23 five-choice, Likert-type scale responses that range from Strongly Disagree (1) to Strongly Agree (5).

The STEBI–A consists of two sub-scales: (a) Personal Science Teaching Efficacy Belief Scale (PSTE) (13 items for self-efficacy determination); and (b) the Science Teaching Outcome Expectancy Scale (STOE) (10 items for the outcome expectancy dimension). The current study utilized the STEBI-A, the Personal Science Teaching Efficacy Belief Scale (PTSE) only (Appendix E). The STEBI-A survey was administered during development to 331 urban and rural practicing teachers; the majority of these respondents were White females representing all elementary school grade levels varied levels of experience. The authors reported that alpha reliability coefficients of the self-efficacy and outcome expectancy dimensions were 0.92 and 0.77, respectively (Riggs & Enochs, 1990). High scores indicate a greater sense of science teaching efficacy (Riggs & Enochs, 1990). Content validity was established through the use of a panel of judges, and construct validity was determined through factor analysis. Convergent and divergent validities were established through homogeneity within and distinctiveness between the subscales.
National Research Center on the Gifted and Talented (NRC/GT) Classroom Practices Teacher Survey Instrument. The CPS instrument (Appendix F) was developed initially to explore the extent to which teachers use differentiated strategies in regular classrooms across the United States. Specifically, the survey was developed to obtain background information on practicing teachers, their classrooms and their school districts, as well as their perceptions of teaching behaviors related to the instruction of gifted and average students in their classes (Archambault et al., 1993). Using stratified random sampling procedures, researchers sampled 3,993 third and fourth grade teachers working in public school settings, 980 private school third and fourth grade teachers, and four samples of third and fourth grade teachers in public schools with high concentrations of African Americans students \((n = 592)\), Asian Americans \((n = 587)\), Hispanic Americans \((n = 582)\) and Native Americans \((n = 580)\).

Using principal factor analysis (Tabachnik & Fidell, 1989), researchers derived six subscales: (a) Questioning and Thinking; (b) Providing Challenges and Choices; (c) Reading and Written Assignments; (d) Curriculum Modifications; (e) Enrichment Centers; and (f) Seatwork. “The Cronbach’s Alpha reliabilities for the six factors were .83, .79, .77, .72, .72, and .53, respectively” (Archambault et al., 1993, p. 104). Content validity for this instrument was established through expert review, field trials, and statistical analyses comparing multiple versions of the survey.

In the current research study, the Thinking and Questioning subscale from the NRC/GT Classroom Practices Teacher Survey (Appendix G) was administered to the participants without the gifted and average annotations. The Thinking and Questioning (Factor 1) subscale consists of 5 items, utilizing a 6-point Likert-type scale from 1 (Never) to
5 (More Than Once a Day); this subscale demonstrated a high alpha reliability of .83 (Archambault et al., 1993). As previously noted, researchers responsible for the development of the STEBI-A and the NRC/GT Classroom Practices, Questioning and Thinking instruments provided written permission for the instruments to be used and published in this study (Appendix H).

Data Collection Procedures

In five districts, the survey was administered and collected during regularly scheduled faculty meetings by the researcher. In two of the remaining districts, a district and a building administrator administered and collected the surveys following their completion. For District E, policy prohibited faculty meetings from being used for research purposes. Therefore, a colleague volunteered to serve as the liaison between the researcher and the school. The colleague distributed the paper survey to interested participants. These surveys were completed and then returned to the colleague’s classroom for collection by the researcher.

The researcher developed a unique anonymous coding system so that each individual survey was assigned to a particular participant at a particular school. A record of completed and missing surveys was maintained to enable the researcher to determine the response rate at each school. A list of these codes was maintained by the researcher in an Excel spreadsheet.

During each administration of the survey by the researcher, a brief introduction to the study’s survey was scripted and then read to the assembled faculty members (see Appendix I). Participants received an Informed Consent Sheet attached to the front of their CSIS (see Appendix J) that informed the participants of: (a) the purpose of the research, (b) the voluntary and confidential nature of the research; and (c) the researcher and WCSU
Institutional Review Board’s (IRB) contact information. In each case, the district personnel had been contacted and granted permission for their district’s participation (see Appendix K), and individual principals had also been contacted and granted permission (see Appendix L).

**Data Analysis and Procedures**

The researcher utilized standard multiple linear regression to analyze research question one and a simple linear regression to analyze research question two. Research questions three and four were analyzed using general qualitative methods. In linear regression, a linear relationship may occur between two variables as demonstrated by a straight line (or line of best fit) or the relationship might be nonlinear, with a curved line which “leads to better predictions from scores on the x-axis to scores on the y-axis” (Gall et al., 2007, p. 347). Multiple linear regression analysis is used to “determine the correlation between the criterion variable and the combination of two or more predictor variables” (Gall et al., 2007, p. 353).

Tabachnick and Fidell (1989) suggest that the necessary sample size for a multiple linear regression is \( N = 50 + 8(m) \), in which \( m \) is equal to the number of independent predictors. Because five of the six predictor variables (gender, grade level taught, highest degree earned, number of science courses taken, and science degree) needed to be dichotomously coded, the number of predictor variables increased to 13. Therefore, the sample size necessary to perform the multiple linear regressions for research question one and the simple linear regression for research question two was approximately 154 participants (Tabachnick & Fidell, 1989). The researcher was able to gain access to the previously described eight elementary schools in the districts reviewed, resulting in an a sample size of 143 teachers, considered adequate. Because these two quantitative research
questions used the same data, alpha level was set to be .025 (.05/2) to minimize the possibility of making a Type I error.

In this study, research question one was analyzed using multiple linear regression analysis. Predictor variables from the demographic items of the CSIS (gender, grade level taught, highest degree earned, years of experience, number of elective undergraduate science courses, and science degree-yes or no) were used to predict the mean sub-scale scores on the STEBI-A (the criterion variable). Five of the predictor variables were categorical variables requiring dichotomous coding as follows: (a) gender with two levels, (b) number of science courses with three levels, (c) highest degree earned with three levels, (d) grade level with six levels, and (e) science degree (yes or no) with two levels. For research question two, the researcher used a simple linear regression analysis to determine whether the STEBI-A self-efficacy response scores from research question one (the predictor variable) predicted frequency of questioning and thinking subscale scores on the CPS (the criterion variable).

Research questions three and four were addressed using three levels of coding techniques—open coding, axial coding, and selective coding, which were applied to the data as suggested by Strauss and Corbin (1998). Data were first coded into open codes. These were then combined into broader categories in axial coding, allowing core categories to emerge during initial selective coding. These were later collapsed into final selective themes. The core categories were verified using an interpretative analysis technique (Gall et al., 2007) to identify general themes that emerged. The quantitative data were later triangulated with the selective themes. Two researchers worked to code the data, checking categories of codes to increase trustworthiness (Gall et al., 2007). An audit trail (Appendix M) was
maintained and reviewed by another researcher. This process will be described in more
detail in chapter four.

**Research Timeline**

The following procedures were followed according to the proposed timeline for the
study. Approval was secured from the Institutional Review Board (IRB) in December, 2010.
Data collection for this study commenced in January, 2011 and concluded in May, 2011.
Prior to obtaining any signatures, the researcher contacted district administrators via
telephone and email to solicit support for the study during the spring of 2011.

Following the data collection completed in May, 2011, the quantitative data were
input into SPSS, version 16.0 (IBM, 2011). Qualitative data were input into a Word
document and later transferred (through the coding process) into Excel (Microsoft, 2007)
spreadsheets. Data cleaning, screening, and analysis commenced and continued during
summer and fall of 2011. All data were checked for accuracy and all appropriate
assumptions were checked for quantitative analyses. The dissertation was written during the
summer, fall and winter of 2011. The dissertation defense occurred in spring of 2012.

In addition to the timeline described above, the researcher maintained an audit trail
(see Appendix M) also known as a reflexive journal to record the various phases and day-to-
day processes of the research project. Lewins and Silver (2007) note that the reflexive
journal offers the qualitative researcher an opportunity to “add to transparency and rigor by
systematically recording such information” (p.166). This audit trail provides information
regarding the process of collecting, reviewing and analyzing data for the research study. A
second researcher verified the audit trail, and an outside auditor reviewed the procedures as
well.
The following procedures were followed according to the timeline.

1. Approval was granted by Western Connecticut’s Institutional Review Board to conduct the study (December, 2010).

2. Following contact with the six individual districts, oral and written approval was granted from the district superintendents of schools from each of the districts. District permission forms (Appendix K) (winter, 2011).

3. Following contact with principals from the eight individual schools, each principal granted written permission for researcher to conduct study (Appendix L) (winter and spring, 2011).

4. Faculties were administered the surveys by the researcher at five of their respective elementary schools; the district administrator administered the surveys at one elementary school in their district; the principal administered the surveys at her elementary school; and a faculty member distributed the survey to interested fellow colleagues at her elementary school. Researcher collected completed surveys (spring, 2011).

5. Data input and analysis occurred (summer and fall 2011).


**Statement of Ethics and Confidentiality**

Permission to participate in this research was sought from each district’s superintendent, each school principal, and all participating teachers. To ensure confidentiality, no names or codes were assigned to the collected data. All data were collected by the researcher and entered into a password protected computer database. Results of the study were made available to those participating principals who requested it.
CHAPTER FOUR

Analysis of Data and Explanation of the Findings

The focus of the current research was to explore the factors related to elementary school classroom teachers' self-efficacy for teaching classroom science and to discover the manner in which self-efficacy beliefs predict the questioning and thinking skills that teachers use in classroom science instruction. Chapter four describes how the results of the statistical procedures addressed the research questions used to guide this investigation. The results are presented in five sections: (a) research questions and hypotheses, (b) results of data cleaning and screening for quantitative items, (c) descriptive results, (d) quantitative data analysis and results for research questions one and two, (e) and qualitative data analysis and findings for research questions three and four.

Research Questions and Hypotheses

1. To what extent and in what manner do the internal factor (gender) and external factors (grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, science degree-yes or no) predict self-efficacy in science teaching for practicing elementary school teachers who teach science in grades K-5?

Alternative non-directional hypothesis:

The internal factor (gender) and external factors (grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, science degree-yes or no) will predict self-efficacy in science teaching for practicing elementary school teachers who teach science in grades K-5.
2. To what extent and in what manner does self-efficacy predict the (self-reported) occurrence of higher order questions for practicing classroom teachers who teach science in grades K-5?

   Alternative hypothesis:
   Self-efficacy will predict the (self-reported) occurrence of higher order questions for practicing classroom teachers who teach science in grades K-5.

3. How do practicing elementary school teachers view the importance of questioning skills in science instruction?

4. What instructional methods do practicing teachers in grades K-5 prefer to use when they teach elementary school science? Why?

**Results of Quantitative Data Input, Cleaning, and Screening**

**Data coding.** The researcher first developed a code book for closed-ended items, displayed in Table 6.
Table 6

*Code Book for Closed-Ended Information from CSIS Survey for Quantitative Analyses*

<table>
<thead>
<tr>
<th>Survey Item Number</th>
<th>Item Description</th>
<th>Value</th>
<th>Entered As</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gender</td>
<td>Male</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Grade Level</td>
<td>K</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1, 2, 3, 4, 5</td>
<td>Exact Value</td>
</tr>
<tr>
<td>3</td>
<td>Years of Experience</td>
<td>Exact Value</td>
<td>Exact value</td>
</tr>
<tr>
<td>4</td>
<td>Highest Degree Earned</td>
<td>BA/BS</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MA/MA</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PhD/EdD</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Elective Undergraduate Science Courses</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5+</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>Science Degree</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>12-24</td>
<td>STEBI-A Items</td>
<td>SA</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 6 (continued)

*Code Book for Closed-Ended Information from CSIS Survey for Quantitative Analyses*

<table>
<thead>
<tr>
<th>Survey Item Number</th>
<th>Item Description</th>
<th>Value</th>
<th>Entered As</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-29</td>
<td>CSI Items</td>
<td>Never, Once a month, or less, Few times monthly, Few times weekly, Daily, More than once a day</td>
<td>0, 1, 2, 3, 4, 5</td>
</tr>
</tbody>
</table>
Qualitative responses were entered into a Microsoft Word document, and quantitative data were initially entered into a Microsoft Excel file (Microsoft, 2007). Qualitative data were then open-coded and entered into a second Microsoft Excel file. Quantitative data were transferred into a statistical computer package, SPSS (Version 16.0) (IBM, 2011), which was later used to analyze the quantitative data.

Data cleaning. Next, the researcher performed a data cleaning and screening procedure to determine whether data were complete and accurate. The initial screening process began with a visual inspection of the SPSS dataset and Excel spreadsheets that had been entered from the results of the Classroom Science Instruction Survey (CSIS) that contained four sections: (a) a set of demographic items, (b) a set of open-ended items, (c) the STEBI-A, and (d) the CPS.

Of the 161 returned surveys, 17 surveys lacked signature authorization and were eliminated from the analysis of data as part of the screening process. One survey was submitted but deemed unusable, as the participant had not been a classroom teacher responsible for science education for the past 4 years. Therefore, 143 completed surveys were considered suitable for analysis.

The data-cleaning procedures determined that the missing values were no more than 5% of the overall dataset. There is some discussion in the statistical literature regarding pairwise and listwise deletion as it concerns missing data and certain statistical procedures. Gerber and Finn (2005) noted that in SPSS, pairwise deletion is the default for bivariate correlational procedures, and listwise deletion is the default for multiple regression procedures. The authors also suggested that a large sample be used, as listwise deletion
greatly reduces the sample size. Because sample size was adequate, the researcher chose to use listwise deletion.

The researcher reversed scored items 13, 15, 16, 18, 20, 21, 22, and 24 from the STEBI-A portion of the CSIS (Appendix A), a process required to ensure that subscale means were correctly computed on these negatively worded items. All data were checked for accuracy, and a frequency table was run for each of the variables to ensure that no value was invalid. Individual scores for the STEBI-A and the CPS were carefully reviewed. Each numerical value was examined for its appropriateness (Meyers et al., 2006). The researcher then used SPSS to calculate subscale mean scores for each participant on the two criterion variables: STEBI-A and CPS scores.

**Analysis of outliers.** The criterion variable for research question one was the mean of the personal self-efficacy subscale of the STEBI-A. Prior to running the data analysis for this research question, the normality of the criterion variable was investigated. Skewness and kurtosis of the residual criterion variable were within the ± 1 range of data normality (Meyers et al., 2006).

Next, the researcher ran box-and-whiskers plots to determine whether any individual outliers existed. According to Meyers et al. (2006), univariate outliers may be seen when there is a separation from the “bulk of the cases” (p.67). The inspection of histograms, box plots and normal probability plots helps to reveal these outliers (Tabachnick & Fidell, 1989). An inspection of these plots revealed that no outliers were found. Because only one of the predictor variables was continuous (years of teaching experience), Mahalanobis distance for multivariate analysis was not required.
The criterion variable for research question two was the mean scores of the questioning and thinking subscale of the CPS. Prior to running the data analysis for this research question, the normality of the criterion variable was investigated and found to be normally distributed. The skewness and kurtosis of the criterion variable were within the ±1 range of data normality (Meyers et al., 2006). An inspection of histograms, box plots and normal probability plots (Tabachnick & Fidell, 1989) revealed the presence of no outliers. Thus, the data for both research questions one and two were deemed to be fit for further analysis.

Descriptive Results

Sample characteristics. A summary of demographic characteristics is presented in this section, which is separated into information relating to gender, grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, and whether or not the participant had obtained a degree in a science field.

Elementary school classroom teachers responsible for teaching science in grades kindergarten through fifth grade participated in this study. Survey data indicated that the majority of the participants, approximately 93% \((n = 133)\), were female and 7% \((n = 10)\) were male. Grade level categories with the most participants included first grade and fourth grade elementary classroom teachers (18.9% each); fifth grade teachers made up only 12.6% of the sample. Table 7 presents grade level characteristics of the participants.
Participants’ years of teaching experience varied from 1 year to 38 years (Figure 1). The mean years of teaching experience for the sample was 13.58. It is interesting to note that a few participants ($n = 3$) had been teaching for more than 35 years.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>$n$</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten</td>
<td>21</td>
<td>14.70</td>
</tr>
<tr>
<td>First Grade</td>
<td>27</td>
<td>18.90</td>
</tr>
<tr>
<td>Second Grade</td>
<td>26</td>
<td>18.20</td>
</tr>
<tr>
<td>Multi-level Grades</td>
<td>2</td>
<td>1.40</td>
</tr>
<tr>
<td>Third Grade</td>
<td>22</td>
<td>15.40</td>
</tr>
<tr>
<td>Fourth Grade</td>
<td>27</td>
<td>18.90</td>
</tr>
<tr>
<td>Fifth Grade</td>
<td>18</td>
<td>12.60</td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Figure 1. The classroom science teaching experience of the participants.

The highest degree earned is displayed as a pie chart in Figure 2. A large percentage of participants, 88.11% \((n = 143)\), had earned a master’s degree.
Figure 2. The highest level of degree: Bachelor through PhD or equivalent of the participating teachers.

Participants were also asked to report the number of elective undergraduate science courses they had taken, and the results are displayed in Table 8 below. Almost half of the participants had taken at least one or two courses \((n = 63)\), and almost a third \((n=43)\) had taken three or more courses. Almost a fourth \((n = 34)\) of participants had taken no courses.
Table 8

*Number of Undergraduate Elective Science Courses Taken by Sample Participants*

<table>
<thead>
<tr>
<th>Number of Elective Science Courses</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 courses</td>
<td>34</td>
</tr>
<tr>
<td>1 -2 courses</td>
<td>63</td>
</tr>
<tr>
<td>3-4 courses</td>
<td>27</td>
</tr>
<tr>
<td>5 or more courses</td>
<td>16</td>
</tr>
<tr>
<td>Total number of teachers</td>
<td>140</td>
</tr>
</tbody>
</table>

Participants were asked if they had earned a science degree. A large majority of participants, 96.5% ($n = 138$), reported that they had not earned a science degree, compared to 3.5% ($n = 5$) who said they had.

**Research Question One**

**Statistical assumptions.** Appropriate statistical assumptions for multiple regression require that the assumptions of normality, linearity, and homoscedasticity must not be violated or the statistical results will not be accurate (Tabachnick & Fidell, 1989). Before the researcher could conduct the appropriate multiple linear regression analysis for research question one, therefore, the following assumptions were checked in SPSS: (a) normality of the criterion variable, (b) linearity, (c) homoscedasticity, and (d) independence of the variables.

A visual inspection of the residual histogram (Figure 3) revealed that residual values for the criterion variable for research question one were normally distributed; skewness and kurtosis values were also within the established range for normality ± 1 (Meyers et al., 2006).
Figure 3. Residual histogram of the dependent variable, the mean of the STEBI-A for research question one.

Linearity refers to the “variables in the analysis” being related “in a linear manner” (Meyers et al., 2006, p. 69). Therefore, linearity procedures allow the researcher to compute the Pearson $r$ to assess the degree of linear relationship among the variables (Meyers et al., 2006). Six scatterplots were analyzed, one at a time, each plotting the six independent variables against the dependent variable, the STEBI-A. When scatterplots are oval shaped, the relationship between the two variables is linear, and the resulting scatterplots satisfied
this requirement. An investigation of the six scatterplots revealed that data appeared to be linearly related.

The assumption of homoscedasticity states that the error values for the quantitative dependent variable, in this case, the mean score for the STEBI-A, will be spread equally across the independent variables (Meyers et al., 2006). According to the authors, heteroscedasticity occurs when the error variance for the criterion variable is not homogeneously distributed across predictor variables. Therefore, the variances among the residuals were examined to determine if the errors themselves were normally distributed across the predicted values. The homoscedasticity of the criterion variable was checked against all the predictor variables, and a visual examination of the z-residual scatterplot in SPSS revealed equal variances among the residual errors.

Next, the independence of the predictors was examined through an examination of the Pearson correlation, the Pearson $r$ (Meyers et al., 2006) between each predictor. According to the authors, the Pearson $r$ indicates the extent to which a “linear relationship exists between two quantitatively measured variables” (Meyers et al., 2006, p.107). The authors also note that “the amount of covariation that exists between the two variables summarizes how the difference in one variable corresponds with the differences in the other” (p. 108). Correlations may vary from +1.00 to -1.00, with larger absolute values of Pearson $r$'s indicating a more direct relationship. Again, the authors explain that moderate correlations are desirable, as they suggest that the variables are appropriately correlated (Meyers et al., 2006).

All categorical predictor variables were changed into dichotomous codes as suggested by Meyers et al. (2006) for multiple regression data analysis to occur. The predictor variable,
Highest Degree Earned, had three levels: BA, MA/MS, and PhD or equivalent. These predictor variables are translated into the following dichotomous codes representing possible values (see Table 9).

Table 9

Dichotomous Codes for Highest Degree Earned

<table>
<thead>
<tr>
<th>Value</th>
<th>Code - DC 1</th>
<th>Code - DC 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor’s Degree - BA/BS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Graduate Degree - MA/MS</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Doctoral Degree or Equivalent - PhD</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The predictor variable of elective undergraduate science courses is referred to as Science Courses Taken, which had four levels: none, one to two courses, three to four courses, and five or more courses. These predictor variables are translated into the following dichotomous codes representing possible values (see Table 10).
Table 10

*Dichotomous Codes for Science Courses Taken*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No Courses</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>One to Two Courses</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Three to Four Courses</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Five or More Courses</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The predictor variable of *Grade Level* had six levels: kindergarten, first grade, second grade, third grade, fourth grade, and fifth grade. These predictor variables are translated into the following dichotomous codes representing possible values (see Table 11).
Table 11

*Dichotomous Codes for Grade Level*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>First Grade</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Second Grade</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Third Grade</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fourth Grade</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fifth Grade</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Stevens (2002) notes that multicollinearity is a problem in multiple regression data analysis as it can reduce the multiple correlation size and can cause an unstable regression equation by increasing the regression coefficient variance. Meyers et al. (2006) note that high correlations may be diagnosed using a tolerance and variance inflation factor statistic that is found in the coefficients table. The authors note that multicollinearity exists if the tolerance values are .01 or less, or if the variance inflation factor statistic is 10 or higher (Meyers et al., 2006). As displayed in Table 12, the tolerance values and the variance inflation factor statistics are within the acceptable range.
Table 12  

*Collinearity Statistics for Research Question One*  

<table>
<thead>
<tr>
<th>Variables</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tolerance</td>
</tr>
<tr>
<td>Gender</td>
<td>.86</td>
</tr>
<tr>
<td>Years of Experience</td>
<td>.94</td>
</tr>
<tr>
<td>Highest Degree Earned -DC1</td>
<td>.63</td>
</tr>
<tr>
<td>Highest Degree Earned-DC2</td>
<td>.63</td>
</tr>
<tr>
<td>Science Courses Taken-DC1</td>
<td>.63</td>
</tr>
<tr>
<td>Science Courses Taken-DC2</td>
<td>.69</td>
</tr>
<tr>
<td>Science Courses Taken-DC3</td>
<td>.70</td>
</tr>
<tr>
<td>Science Degree</td>
<td>.82</td>
</tr>
<tr>
<td>Grade Level-DC1</td>
<td>.52</td>
</tr>
<tr>
<td>Grade Level-DC2</td>
<td>.53</td>
</tr>
<tr>
<td>Grade Level-DC3</td>
<td>.53</td>
</tr>
<tr>
<td>Grade Level-DC4</td>
<td>.51</td>
</tr>
<tr>
<td>Grade Level- DC5</td>
<td>.57</td>
</tr>
</tbody>
</table>

Table 13 presents the means and standard deviations for the variables in the model. An examination of the bivariate correlations revealed that the predictor variables of gender, grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, and science degree (yes or no) were somewhat, although not overly, correlated with each other. Therefore, the data for research question one were deemed to be acceptable for the purpose of this study. The means and standard deviations
for all variables in the data are displayed in Table 13, and the inter-correlations for the variables are displayed in Table 14 that follows.

Table 13

 Means and Standard Deviations for Variables for Research Question One

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of the STEBI-A</td>
<td>3.80</td>
<td>.53</td>
</tr>
<tr>
<td>Gender</td>
<td>.93</td>
<td>.26</td>
</tr>
<tr>
<td>Years of Experience</td>
<td>13.63</td>
<td>7.81</td>
</tr>
<tr>
<td>Highest Degree Earned</td>
<td>.97</td>
<td>.34</td>
</tr>
<tr>
<td>Science Courses Taken</td>
<td>1.18</td>
<td>.93</td>
</tr>
<tr>
<td>Science Degree</td>
<td>.04</td>
<td>.18</td>
</tr>
<tr>
<td>Grade Level</td>
<td>2.44</td>
<td>1.63</td>
</tr>
</tbody>
</table>
Table 14

Summary of Inter-correlations of Variables for Research Question One

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1.00</td>
<td>-0.11</td>
<td>-0.06</td>
<td>0.14*</td>
<td>-0.07</td>
<td>-0.07</td>
<td>0.10</td>
</tr>
<tr>
<td>2.</td>
<td>1.00</td>
<td>0.10</td>
<td>-0.02</td>
<td>0.06</td>
<td>0.08</td>
<td>-0.15*</td>
</tr>
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<td>3.</td>
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<td>-0.03</td>
<td>-0.02</td>
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<td>1.00</td>
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<td>-0.57**</td>
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<td>5.</td>
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<td></td>
<td>0.17*</td>
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<td>6.</td>
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<td></td>
<td></td>
<td>-0.43**</td>
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<td>7.</td>
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<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note. * p < .05; ** p < .01; *** p < .00
Table 14 (continued)

Summary of Inter-correlations of Variables for Research Question One

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>.37**</td>
<td>.18*</td>
<td>-.05</td>
<td>-.07</td>
<td>-.05</td>
<td>.16*</td>
</tr>
<tr>
<td>2.</td>
<td>.01</td>
<td>-.25**</td>
<td>.06</td>
<td>.06</td>
<td>.05</td>
<td>-.15*</td>
</tr>
<tr>
<td>3.</td>
<td>.14*</td>
<td>.02</td>
<td>.06</td>
<td>.08</td>
<td>-.12</td>
<td>-.05</td>
</tr>
<tr>
<td>4.</td>
<td>.06</td>
<td>-.05</td>
<td>.07</td>
<td>.11</td>
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<td>.01</td>
</tr>
<tr>
<td>5.</td>
<td>-.08</td>
<td>-.04</td>
<td>-.10</td>
<td>-.01</td>
<td>.09</td>
<td>.08</td>
</tr>
<tr>
<td>6.</td>
<td>-.31</td>
<td>-.17*</td>
<td>.15*</td>
<td>-.15*</td>
<td>-.02</td>
<td>.04</td>
</tr>
<tr>
<td>7.</td>
<td>-.17*</td>
<td>.01</td>
<td>-.01</td>
<td>.11</td>
<td>.02</td>
<td>-.14*</td>
</tr>
<tr>
<td>8.</td>
<td>1.00</td>
<td>.29**</td>
<td>-.12</td>
<td>.07</td>
<td>-.10</td>
<td>.17*</td>
</tr>
<tr>
<td>9.</td>
<td>1.00</td>
<td>-.09</td>
<td>.01</td>
<td>-.09</td>
<td>.20*</td>
<td>-.07</td>
</tr>
<tr>
<td>10.</td>
<td>1.00</td>
<td>-.22*</td>
<td>-.22*</td>
<td>-.24*</td>
<td>-.19*</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>1.00</td>
<td>-.21*</td>
<td>-.22*</td>
<td>-.18*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* $p < .05$; **$p < .01$; ***$p < .001$
Table 14 (continued)

*Summary of Inter-correlations of Variables for Research Question One*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12.</td>
<td>1.00</td>
<td>-.22*</td>
<td>-.17*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td>1.00</td>
<td>-.19*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p < .05; ** p < .01; *** p < .001
**Description and justification of the analyses.** Standard multiple linear regression was utilized to address research question one. According to Meyers et al. (2006), multiple linear regression is most appropriate when “using more than one predictor can paint a more complete picture of how the world works than is permitted by simple linear regression because constructs in the behavioral sciences are believed to be multiply determined” (p. 147). For research question one, the researcher chose a standard regression method of analysis rather than a stepwise method of building the multiple regression equation based on Meyers et al. (2006) multiple regression research. In a standard method of multiple regression analysis, all of the predictors are entered into the standardized score equation in one step. Meyers et al. (2006) note that an advantage of using the standard regression model is that the researcher has the opportunity to select possible predictors based on a theoretical model or a review of the literature, as in the current study.

Predictor variables for research question one were gender, number of years of experience teaching science, grade level taught, number of elective undergraduate science courses, highest degree earned, and science degree (yes or no). The following variables were categorical: gender, grade level, number of elective undergraduate science courses, highest degree earned, and science degree (yes or no). Dichotomous coding using 0s and 1s was therefore necessary before performing regression procedures. The criterion variable for research question one consisted of the mean subscale score for the STEBI-A.

**Results for research question one.** To what extent and in what manner do the internal factor (gender) and external factors (grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, science degree-yes or no)
predict self-efficacy in science teaching for practicing elementary school teachers who teach science in grades K-5?

Standard linear multiple regression was conducted with the means of the STEBI-A as the criterion variable and gender, grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, and science degree (yes or no) as predictor variables. Meyers et al. (2006) suggest that multiple univariate tests require an adjustment to the alpha level which “reduces the possibility of operating with an inflated Type I error rate” (p. 373). This procedure is known as a Bonferroni correction. A Bonferroni adjusted alpha level of .025 (.05/2) was applied, because the two research questions used the same data.

The regression model was significant $F (13, 141) = 3.78, p < .001, f^2 = .26$, a small effect size. Together, the variables in the model explained 20.4% of the variation in teachers’ science self-efficacy. Within the model, the dichotomous codes for 3-5 science courses ($p = .008$), more than 5 science courses ($p < .001$) and fifth-grade grade level ($p = .014$) were significant predictors of science self-efficacy as demonstrated by the STEBI-A scores. The remaining variables, gender, highest degree earned, years of experience, and science degree were not significant at the .025 alpha level. Results of the regression analysis are presented in Table 15.
Table 15

**Predictors of Mean Scores on the STEBI-A Science Self-Efficacy Measure**

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SEB</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>3.26</td>
<td>.26</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-.02</td>
<td>.17</td>
<td>-.01</td>
</tr>
<tr>
<td>Years of Experience</td>
<td>-.01</td>
<td>.01</td>
<td>-.11</td>
</tr>
<tr>
<td>Highest Degree Earned – DC1</td>
<td>.29</td>
<td>.16</td>
<td>.17</td>
</tr>
<tr>
<td>Highest Degree Earned – DC2</td>
<td>.10</td>
<td>.25</td>
<td>.04</td>
</tr>
<tr>
<td>Science Courses Taken – DC1</td>
<td>.20</td>
<td>.10</td>
<td>.19</td>
</tr>
<tr>
<td>Science Courses Taken – DC2</td>
<td>.33</td>
<td>.12</td>
<td>.24*</td>
</tr>
<tr>
<td>Science Courses Taken – DC3</td>
<td>.81</td>
<td>.15</td>
<td>.48***</td>
</tr>
<tr>
<td>Science Degree</td>
<td>.24</td>
<td>.24</td>
<td>.08</td>
</tr>
<tr>
<td>Grade Level – DC1</td>
<td>.15</td>
<td>.14</td>
<td>.11</td>
</tr>
<tr>
<td>Grade Level – DC2</td>
<td>.03</td>
<td>.14</td>
<td>.02</td>
</tr>
<tr>
<td>Grade Level – DC3</td>
<td>.18</td>
<td>.15</td>
<td>.13</td>
</tr>
<tr>
<td>Grade Level – DC4</td>
<td>.25</td>
<td>.14</td>
<td>.18</td>
</tr>
<tr>
<td>Grade Level – DC5</td>
<td>.40</td>
<td>.16</td>
<td>.25*</td>
</tr>
</tbody>
</table>

*Note. Regression Analysis Summary for Gender, Years of Experience, Highest Degree Earned DC1, DC2, Science Courses Taken DC1, DC2, DC3, Science Degree, and Grade Level DC1, DC2, DC3, DC4, DC5; Adj. $R^2 = .20$ ($n = 142$; $p < .05$, **$p < .01$; ***$p < .001$). Again, all predictors were tested at the .025 alpha level. Three of the predictors, the two dichotomous codes indicating three or more undergraduate elective science courses taken and the one dichotomous code for fifth grade teachers, contributed significantly to the prediction of self-efficacy as reported on the STEBI-A. The number of science courses*
positively correlated with mean scores on the STEBI-A, as did the dichotomous code for fifth grade teachers. To summarize, as the number of participants’ elective undergraduate courses increased to three or more, teachers’ self-efficacy increased significantly. Similarly, self-efficacy also increased significantly as the coding switched to indicate fifth grade teachers.

**Research Question Two**

**Statistical assumptions.** Appropriate statistical assumptions for simple linear regression require that the same assumptions of normality, linearity, and homoscedasticity must not be violated, or the statistical results will not be accurate (Tabachnick & Fidell, 1989). Therefore, before the researcher could conduct the appropriate simple linear regression analysis for research question two, the following assumptions were checked in SPSS: (a) normality of the error variance for the criterion variable, (b) linearity, (c) homoscedasticity, and (d) independence of the variables.

For normality of the criterion variable to be tested, a visual inspection of the residual histogram was made which revealed that the criterion variable for research question one was found to be fairly normal (see Figure 4). The skewness and kurtosis values are reported in Table 16.
**Figure 4.** Residual histogram of the dependent variable, the mean of the Classroom Practices Survey (CPS) for research question two

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Statistic</th>
<th>StandardError</th>
<th>Statistic</th>
<th>StandardError</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of the STEBI-A</td>
<td>142</td>
<td>-.42</td>
<td>.20</td>
<td>.24</td>
<td>.40</td>
</tr>
<tr>
<td>Means of the CPS</td>
<td>141</td>
<td>-1.18</td>
<td>.20</td>
<td>1.55</td>
<td>.41</td>
</tr>
</tbody>
</table>

Although the skewness and kurtosis values for the variables were somewhat high, some researchers (D’Agostino, Belanger, & D’Agostino, 1990) report that these values may
approach absolute 2 and still be deemed appropriate for determining the normality of the criterion variable.

Again, linearity refers to the “variables in the analysis” being related “in a linear manner” (Meyers et al., 2006, p. 69). A scatterplot between the predictor variable (mean of the STEBI-A) and the criterion variable (mean of the CPS) was elliptical, which demonstrated a linear relationship between the two variables.

As stated by Meyers et al. (2006), the assumption of homoscedasticity requires that the variance of the quantitative dependent variable, in this case, the error variance on the CPS, is evenly distributed across the scores on the STEBI-A. The homoscedasticity of the CPS, the criterion variable, was checked against the means of the self-efficacy scores on the STEBI-A, the predictor variable. A visual examination of the z-residual scatterplot in SPSS revealed equal variances among the residual errors.

**Description and justification of the analyses.** Simple linear regression was utilized to address research question two. According to Meyers et al. (2006), simple linear regression is an analysis that utilizes a single variable, the predictor variable, to predict another single variable, the criterion variable. The predictor variable for research question two was the STEBI-A. The criterion variable for research question two consisted of the mean subscale score for the questioning and thinking section on the CPS.

**Results for research question two.** To what extent and in what manner does self-efficacy predict the (self-reported) occurrence of higher order questions for practicing classroom teachers who teach science in grades K-5?
Simple linear regression was conducted with the mean of the CPS as the criterion variable and the mean of the STEBI-A as the predictor variable. The means and standard deviations are displayed in Table 17.

Table 17

*Descriptive Statistics for Research Question Two*

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means of the CPS</td>
<td>4.39</td>
<td>.63</td>
<td>141</td>
</tr>
<tr>
<td>Means of the STEBI-A</td>
<td>3.80</td>
<td>.53</td>
<td>141</td>
</tr>
</tbody>
</table>

The mean of the STEBI-A variable was correlated with the mean of the CPS ($p < .01$). A small positive effect size is noted for increased self-efficacy as demonstrated by the scores on the STEBI-A when correlated with performance scores on the CPS (Table 18).

Table 18

*Correlations for Research Question Two Variables*

<table>
<thead>
<tr>
<th></th>
<th>Mean of the CPS</th>
<th>Mean of the STEBI - A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>Mean of the CPS</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Mean of the STEBI - A</td>
<td>.26**</td>
</tr>
</tbody>
</table>

* $p < .05$   ** $p < .01$

Again, a Bonferroni adjusted alpha level of .025 (.05 /2) was applied to minimize the possibility of making a Type I error. The model was significant $F (1, 139) = 9.806, p = .002$, $f^2 = .06$, a trivial effect size (Table 19). Within the model, the mean of the STEBI-A was a significant predictor ($p = .002$) of increased performance on the CPS as demonstrated by the CPS scores.

A little more than 6% (6.6%) of the variation for the mean of the CPS was predicted by scores on the STEBI-A. As the mean scores on the STEBI-A increased, the scores on the
CPS increased. Therefore, as teachers’ self-efficacy increased, they utilized questioning and thinking methods more frequently.

Table 19

Model Summary for Research Question Two

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>SEB</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>2.84</td>
<td>.31</td>
<td>1</td>
</tr>
<tr>
<td>Mean of the CPS</td>
<td>.22</td>
<td>.07</td>
<td>.26*</td>
</tr>
</tbody>
</table>

Note. Adj. R² = .066; *p < .05 **p < .01

Qualitative Data Analyses for Research Questions Three and Four

In addition to the demographic items and the STEBI-A and CPS surveys, The Classroom Science Instruction Survey contained five open-ended items: numbers 7, 8, 9, 10, and 11. The purpose of these open-ended responses was to triangulate the participants’ underlying thinking of the elementary school science classroom instruction with the data collected from the quantitative analysis of research questions one and two. This portion of the chapter is therefore organized into procedures for the qualitative data analysis for research questions three and four and the triangulation of quantitative and qualitative results.

Open-ended items and their relationship to research questions three and four.

Lincoln and Guba (1985) refer to qualitative data analysis as “induction” (p. 333), where the researcher is made aware of the respondents’ natural language as they share their thoughts, opinions, and beliefs. The researcher developed open-ended items to address the qualitative nature of the research questions. Table 20 displays the open-ended items and their relationship to the research questions.
Table 20

*Open-ended Survey Questions and Corresponding Research Questions*

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Survey Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three: How do practicing elementary school teachers view the importance of</td>
<td>11. How do you encourage students’ questioning and thinking skills in your</td>
</tr>
<tr>
<td>questioning skills in science instruction?</td>
<td>classroom?</td>
</tr>
<tr>
<td>Four: What instructional methods do practicing teachers in grades K-5 prefer to</td>
<td>7. How do good teachers teach elementary school science well?</td>
</tr>
<tr>
<td>use when they teach elementary school science? Why?</td>
<td></td>
</tr>
<tr>
<td>Four: What instructional methods do practicing teachers in grades K-5 prefer to</td>
<td>8. Are there any experiences outside the classroom that you believe have</td>
</tr>
<tr>
<td>use when they teach elementary school science? Why?</td>
<td>increased your effectiveness as a classroom science teacher?</td>
</tr>
<tr>
<td>Four: What instructional methods do practicing teachers in grades K-5 prefer to</td>
<td>9. What do you think you do well when teaching science?</td>
</tr>
<tr>
<td>use then they teach elementary school science? Why?</td>
<td></td>
</tr>
<tr>
<td>Four: What instructional methods do practicing teachers in grades K-5 prefer to</td>
<td>10. What are some of the challenges you face when teaching science?</td>
</tr>
<tr>
<td>use then they teach elementary school science? Why?</td>
<td></td>
</tr>
</tbody>
</table>
**Coding and inductive analysis.** According to Creswell and Clark (2007), the core of qualitative data analysis involves coding, or the “grouping evidence and labeling ideas so they reflect increasingly broader perspectives” (p. 208). In the current study, the researcher transcribed the exact words from the participants and then divided the text into small units of phrases called open codes. These open codes were then assigned a label, as suggested by Creswell and Clark (2007) with the concepts typically used in social science literature. Following this hand-coding process, the codes were then grouped into broader axial codes followed by selective themes.

The open codes were entered into separate cells of a Microsoft Excel spreadsheet. These codes were based on specific descriptions of the responses selected for each numbered item. Lincoln and Guba (1985) note that a feature of a more “naturalistic paradigm” (p. 203) is that the investigator allows the theory to emerge from the inquiry. Inductive analysis “begins not with theories or hypotheses but with the data themselves, from which theoretical categories and relational propositions may be arrived at by inductive reasoning processes” (Lincoln & Guba, 1985, p. 333). The open data codes therefore emerged from the words used by respondents in the open-ended portion of the survey items.

The open codes were then summed into initial axial codes. According to Miles and Huberman (1994), the categories “are reviewed, and typically, a more abstract category is attributed to several incidents or observations” (p. 58). Therefore, multiple open responses were collapsed into axial codes. Appendix N contains the list of open code responses and related axial codes for survey items 7 through 11.

For example, one participant responded with two similar comments to survey response item seven, *How do good teachers teach elementary school science well?* The participant shared
that “[teachers] access prior knowledge” and that “[teachers] build on known ideas.” These two open responses were collapsed into one axial code, *science content*. Axial codes were reviewed further and collapsed into initial selective themes, which were then analyzed and collapsed even further into final selective themes. To further exemplify the process, science content, the axial code, was then collapsed with other axial codes into the initial selective theme, *Pedagogical Concerns: Specific Strategies*. This initial selective theme was collapsed even further into the final selective theme, *Teachers believe that they use specific inquiry-based practices in the elementary classroom*.

The researcher and a second researcher checked all codes for consistency. An auditor reviewed the audit trail as well. If there was a discrepancy in the coding, it was discussed and the researchers came to a consensus in agreement.

**Results for research question three.** How do practicing elementary school teachers view the importance of questioning skills in science instruction?

In the quantitative analysis of research question two, the overall mean for the total sample on the CPS was 4.39 on a 6-point Likert scale, indicating that most participants utilized questioning strategies at least daily. This high level of use alone suggests that these participants viewed questioning skills as important in science instruction. The qualitative data provided support for this finding and further illuminated how participants viewed the importance of questioning.

The researcher first reviewed the open-coded data from participants on survey item 11; these 277 open codes were then categorized into 10 axial codes representing patterns. The 10 axial codes from the response data collected from survey item number 11, along with a percentage of responses that dealt with each code, are displayed in Table 21.
Table 21

*Initial Axial Codes for Qualitative Data for Survey Item 11: How Do You Encourage Students’ Questioning and Thinking Skills in Your Classroom?*

<table>
<thead>
<tr>
<th>Number of Code</th>
<th>Description of Axial Code</th>
<th>Percentage of Responses ($n=277$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Encouragement of Wonder / Curiosity</td>
<td>10.47</td>
</tr>
<tr>
<td>2</td>
<td>Content-based Strategies</td>
<td>13.72</td>
</tr>
<tr>
<td>3</td>
<td>Meta-cognitive Strategies</td>
<td>5.42</td>
</tr>
<tr>
<td>4</td>
<td>Inquiry-based Strategies</td>
<td>13.00</td>
</tr>
<tr>
<td>5</td>
<td>Positive Classroom Environment</td>
<td>23.10</td>
</tr>
<tr>
<td>6</td>
<td>Relevant Science Learning Experiences</td>
<td>4.69</td>
</tr>
<tr>
<td>7</td>
<td>Student Questioning Development</td>
<td>11.55</td>
</tr>
<tr>
<td>8</td>
<td>Open-ended/Creative/Higher Order Question Development</td>
<td>6.50</td>
</tr>
<tr>
<td>9</td>
<td>Brainstorming Techniques</td>
<td>1.08</td>
</tr>
<tr>
<td>10</td>
<td>Promotion of Peer Discussion and Interaction</td>
<td>10.47</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

These 10 axial codes were then perused by the researcher as she reviewed the data for themes representing selective codes. Three initial selective codes emerged and are presented along with the percentage of responses that fell into each code, in Table 22 below.
Table 22

*Initial Selective Themes for Survey Item 11: How Do You Encourage Students’ Questioning and Thinking Skills in Your Classroom?*

<table>
<thead>
<tr>
<th>Theme Number</th>
<th>Initial Selective Theme</th>
<th>Percentage of Responses (n = 277)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td><strong>Fostering Student Interest:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Encouragement of Wonder and Curiosity</td>
<td>10.47</td>
</tr>
<tr>
<td></td>
<td>Positive Classroom Environment</td>
<td>23.10</td>
</tr>
<tr>
<td></td>
<td>Relevant Science Learning Experiences</td>
<td>4.69</td>
</tr>
<tr>
<td></td>
<td><strong>Total for 3.1- Fostering Student Interest</strong></td>
<td>38.27</td>
</tr>
<tr>
<td>3.2</td>
<td><strong>Teacher Based Strategies that Encourage Student Questioning:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brainstorming Techniques</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td>Development of Student Questioning</td>
<td>11.55</td>
</tr>
<tr>
<td></td>
<td>Development of Non-Closed Questions</td>
<td>6.50</td>
</tr>
<tr>
<td></td>
<td>Promotion of Peer Discussion and Interaction</td>
<td>10.47</td>
</tr>
<tr>
<td></td>
<td><strong>Total for 3.2-Teacher Based Strategies that Encourage Student Questioning</strong></td>
<td>29.60</td>
</tr>
<tr>
<td>3.3</td>
<td><strong>Curriculum–based Strategies that Encourage Student Questioning:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Content Based Strategies</td>
<td>13.72</td>
</tr>
<tr>
<td></td>
<td>Metacognitive Strategies</td>
<td>5.42</td>
</tr>
<tr>
<td></td>
<td>Inquiry –Based Strategies</td>
<td>13.00</td>
</tr>
<tr>
<td></td>
<td><strong>Total for 3.3-Curriculum-based Strategies that Encourage Student Questioning</strong></td>
<td>32.13</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>100.00</td>
</tr>
</tbody>
</table>
Over a third of the responses to survey item 11 dealt with teachers’ efforts to foster students’ interest in science learning to develop their questioning skills. As one participant stated, “[We] impress on our young students that ‘we are all scientists,’ whatever we are learning.” Other participants discussed the importance of developing and maintaining a positive classroom environment for science learning to occur, stressing that “all questions are important.” A few participants indicated that relevant science learning experiences, activities that connect science with real life, were also important in fostering students’ questions. One participant stated that she provides “real-life examples.”

Almost a third of responses dealt with the strategies that teachers used to encourage student questioning. As one participant reported, “turn and talk discussions” are important. Some participants spoke of ways to develop student questioning. One participant asked the question, “What do you think will happen if?” A few participants discussed the development of open-ended, higher order questions. As one participant stated, “[teachers should] ask open-ended questions through observation.” Some of the participants noted the importance of promoting peer discussion and interaction, by “allowing students to express their opinions,” encouraging “group work,” and “partnership work.” One participant noted that “when they [students] have questions we brainstorm ways to find answers.”

Approximately a third of the responses dealt with curriculum–based strategies that encourage student questioning. Content-based strategies such as using the outdoors as a teaching environment and modeling teacher thinking were reported. Metacognitive strategies were also reported, as when one participant noted that “students write questions on post-its. [Teachers should] begin all units by asking the children what they know and what they want to know.” Participants also discussed inquiry-based strategies in terms of doing labs and
conducting experiments. One participant reported, “[I] share the different ways in which the children figured out the solution to the problem. I feel this helps kids develop a variety of strategies to try when confronted with a problem.”

**Results for research question four.** What instructional methods do practicing teachers in grades K-5 prefer to use when they teach elementary school science? Why?

Of the five open-ended items, the Classroom Science Instruction Survey contained four items which provided the researcher with information necessary to respond to this question: items number 7, 8, 9, and 10.

*Survey item 7: How do good teachers teach elementary school science well?* To analyze this item, the researcher open-coded data from participants who responded, and these 353 open codes were then categorized into 12 axial codes representing patterns. The 12 axial codes from the response data collected from survey item number 7, along with a percentage of responses that dealt with this code, are displayed in Table 23.
Table 23

*Initial Axial Codes for Qualitative Data for Survey Item 7: How Do Good Teachers Teach Elementary School Science Well?*

<table>
<thead>
<tr>
<th>Number of Code</th>
<th>Description of Axial Code</th>
<th>Percentage of Responses (n = 353)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Learning Styles/Teacher Delivery Styles</td>
<td>2.55</td>
</tr>
<tr>
<td>2</td>
<td>Unique Experiences/Pleasure Activities</td>
<td>1.42</td>
</tr>
<tr>
<td>3</td>
<td>Formative Assessment</td>
<td>4.25</td>
</tr>
<tr>
<td>4</td>
<td>Teacher Characteristics and Knowledge</td>
<td>11.61</td>
</tr>
<tr>
<td>5</td>
<td>Props, Resources, Time and Materials</td>
<td>13.31</td>
</tr>
<tr>
<td>6</td>
<td>Hands-on Opportunities for Science Learning</td>
<td>25.50</td>
</tr>
<tr>
<td>7</td>
<td>Constructivism...Exploration, Inquiry, Observation, Discovery</td>
<td>23.51</td>
</tr>
<tr>
<td>8</td>
<td>Science Relevance</td>
<td>3.12</td>
</tr>
<tr>
<td>9</td>
<td>Questioning</td>
<td>5.95</td>
</tr>
<tr>
<td>10</td>
<td>Science Content</td>
<td>3.97</td>
</tr>
<tr>
<td>11</td>
<td>Teacher Collaboration</td>
<td>1.13</td>
</tr>
<tr>
<td>12</td>
<td>Multi-disciplinary</td>
<td>3.68</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

These 12 axial codes were then perused by the researcher as she explored the data for initial selective themes. Three initial selective codes emerged and are presented, along with the percentage of responses that fell into each code, in Table 24 below.
Table 24

*Initial Selective Themes for Survey Item 7: How Do Good Teachers Teach Elementary School Science Well?*

<table>
<thead>
<tr>
<th>Theme Number</th>
<th>Initial Selective Theme</th>
<th>Percentage of Responses (n =353)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Pedagogical Concerns: Inductive Learning:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hands on Opportunities for Science Learning</td>
<td>25.50</td>
</tr>
<tr>
<td></td>
<td>Constructivism Method for Instruction</td>
<td>23.51</td>
</tr>
<tr>
<td></td>
<td><strong>Total for 4.1-Pedagogical Concerns –Inductive Learning</strong></td>
<td><strong>49.01</strong></td>
</tr>
<tr>
<td>4.2</td>
<td>Pedagogical Concerns: Specific Strategies:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learning Styles</td>
<td>2.55</td>
</tr>
<tr>
<td></td>
<td>Formative Assessment</td>
<td>4.25</td>
</tr>
<tr>
<td></td>
<td>Science Relevance</td>
<td>3.12</td>
</tr>
<tr>
<td></td>
<td>Science Content</td>
<td>3.97</td>
</tr>
<tr>
<td></td>
<td>Multi-disciplinary Approach</td>
<td>3.68</td>
</tr>
<tr>
<td></td>
<td>Questioning Skills</td>
<td>5.95</td>
</tr>
<tr>
<td></td>
<td>Props, Materials, Time, Resources</td>
<td>13.31</td>
</tr>
<tr>
<td></td>
<td><strong>Total for 4.2-Pedagogical Concerns-Specific Strategies</strong></td>
<td><strong>36.83</strong></td>
</tr>
<tr>
<td>4.3</td>
<td>Specific Teacher Characteristics, Experiences, and Knowledge:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unique Experiences and Pleasure Activities</td>
<td>1.42</td>
</tr>
<tr>
<td></td>
<td>Teacher Characteristics and Knowledge</td>
<td>11.61</td>
</tr>
<tr>
<td></td>
<td>Teacher Collaboration</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td><strong>Total for 4.3-Specific Teacher Characteristics, Experiences, and Knowledge</strong></td>
<td><strong>14.16</strong></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>
Approximately half of the responses to survey item 7 dealt with the pedagogical concerns of inductive learning. One participant noted that during inductive learning, teachers “teach kids to observe their world and wonder. Science should be a combination of hands-on experiences incorporating all content areas, including (non-fiction and reading for information), writing (detailed, descriptive language when recording observations, etc.) and mathematics (recording and analyzing data, etc.).” Some of the teachers responded by stating that good classroom science teachers teach science well by offering students hands-on opportunities to experience science. As one participant stated, “They [teachers] have a solid understanding of the content being taught, they offer hands-on projects and lead their students through inquiry-based learning.” Other teachers in this selective theme spoke of the constructivist method for instruction, suggesting that teachers are responsible for providing “students with opportunities to think, to wonder, and to apply ideas related to scientific inquiry.”

Approximately a third of the responses reported on the specific pedagogical strategies that teachers used to promote inductive learning, such as attention to student learning styles, assessment that is more authentic and shapes curriculum. As one participant noted, “clear [state] standards” are necessary, with others suggesting that good teachers check for understanding using a variety of methods such as written and oral explanations of science phenomena. Teachers shared their concerns regarding the lack of science content knowledge for themselves as well as for their students. Teachers also spoke of the need for making science more relevant and meaningful for their students by connecting it to other subject areas. Some of the participants discussed the importance of questioning skills by noting that good teachers encourage students to identify essential questions and pose others. One
participant stated that good teachers “appreciate questioning” and another stated that good teachers “investigate questions that interest students.” Some of the respondents in this selective theme spoke of the need for science props, materials, time and resources to be varied, plentiful and up-to-date. Instructional technology, for example, was a recurring theme. One participant stated that good teachers “[use] different modalities of instruction, videos, photographs, computer programs,” to teach science well.

A minority of responses dealt with the importance of teacher characteristics. Some participants reported that teachers should have a strong background in science and know the subject they are teaching. One participant stated that teachers “get to know the curriculum well by experiencing it.” Another stated that teachers need to “show a passion for science.” Others reported that unique science experiences and pleasure activities as well as teacher collaboration are important teacher characteristics for teachers who teach elementary school science well.

Survey item 8: Are there any experiences outside the classroom that you believe have increased your effectiveness as a classroom science teacher? Again, for survey item 8, the researcher open-coded data from participants, and these 216 open codes were then categorized into six axial codes representing patterns. The six axial codes from the response data collected from survey item number 8, along with a percentage of responses that dealt with this code, are displayed in Table 25.
Table 25

*Initial Axial Codes for Qualitative Data for Survey Item 8: Are There Any Experiences Outside the classroom that You Believe Have Increased Your Effectiveness as a Classroom Science Teacher?*

<table>
<thead>
<tr>
<th>Number of Code</th>
<th>Description of Axial Code</th>
<th>Percentage of Responses (n =216)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Travel Experiences</td>
<td>33.33</td>
</tr>
<tr>
<td>2</td>
<td>Hobbies</td>
<td>15.74</td>
</tr>
<tr>
<td>3</td>
<td>Non-school Science Related Experiences</td>
<td>4.17</td>
</tr>
<tr>
<td>4</td>
<td>Teacher Characteristics</td>
<td>12.50</td>
</tr>
<tr>
<td>5</td>
<td>Teacher Knowledge Advancement</td>
<td>16.67</td>
</tr>
<tr>
<td>6</td>
<td>Professional Development</td>
<td>17.59</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

These six axial codes for survey item 8 were then perused by the researcher as she reviewed the data looking for themes representing initial selective themes. Two initial selective themes emerged and are presented, along with the percentage of responses that fell into each code, in Table 26 below.
Table 26

Initial Selective Themes for Survey Item 8 for Research Question Four: Are There Any Experiences Outside the classroom that You Believe Have Increased Your Effectiveness as a Classroom Science Teacher?

<table>
<thead>
<tr>
<th>Theme Number</th>
<th>Initial Selective Theme</th>
<th>Percentage of Responses (n = 216)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4</td>
<td>Exploration of Science:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Travel Experiences</td>
<td>33.33</td>
</tr>
<tr>
<td></td>
<td>Hobbies</td>
<td>15.74</td>
</tr>
<tr>
<td></td>
<td>Non-School Science Related Experiences</td>
<td>4.17</td>
</tr>
<tr>
<td></td>
<td>Teacher Characteristics</td>
<td>12.50</td>
</tr>
<tr>
<td></td>
<td>Total for 4.4-Exploration of Science</td>
<td>65.74</td>
</tr>
<tr>
<td>4.5</td>
<td>Life-Long Science Learners:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowledge Advancement</td>
<td>16.67</td>
</tr>
<tr>
<td></td>
<td>Professional Development</td>
<td>17.59</td>
</tr>
<tr>
<td></td>
<td>Total for 4.5-Life-Long Science Learners</td>
<td>34.26</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

More than two-thirds of responses to survey item 8 dealt with the exploration of science as an experience outside the classroom, which participants believed increased their effectiveness as classroom science teachers. In addition to travel and various hobbies, one participant reported that it was important to “look at most of my everyday experiences inquisitively which in return comes back to the classroom.” Many of the participants listed area nature centers, botanical gardens, and science museums as travel opportunities that helped to teach them more about science. As one participant reported, “since I teach earth
science, I have visited volcanoes in Greece and Italy and brought home ‘souvenirs’ for my class.” Some of the participants listed hobbies such as gardening, hiking and keeping pets as helpful experiences. An important non-school related experience mentioned by another participant was “just doing a lot of activities with my family.” A few participants indicated that teacher characteristics which promote this exploration of science are important as well. As one participant noted, “Any time I ‘connect with nature’ it enhances my excitement about science.” However, another participant in response to the same item stated that, “having done poorly as a science student has propelled me to teach well.”

Another third of responses to this item dealt with teachers’ beliefs that becoming life-long science learners increased their effectiveness as classroom science teachers. Some participants discussed the importance for knowledge advancement to increase effectiveness as a classroom teacher. Some participants noted the variety of science programming available to teachers at area stores, on-line, and at their schools. As one participant stated, “Watching Discovery Channel, etc., getting DVD’s from the Discovery Store to use for note-taking and other curricular skills and just plain enjoyment increases curiosity about the world around us.” In addition, some participants reported on various professional development opportunities available to them, such as courses at various colleges, universities, and teacher centers. One participant noted her participation in “professional development in inquiry-based education.” Another mentioned “life experiences involving science and scientists” as being an important professional development experience.

**Survey item 9: What do you think you do well when you are teaching science?**

Again, the researcher open-coded data from participants on survey item 9, and these 263 open codes were then categorized into 10 axial codes representing patterns. The 10 axial
codes from the response data collected from survey item 9, along with a percentage of responses that dealt with this code, are displayed in Table 27.

Table 27

_initial axial codes for qualitative data for survey item 9: What do you think you do well when you are teaching science?

<table>
<thead>
<tr>
<th>Number of Code</th>
<th>Description of Axial Code</th>
<th>Percentage of Responses (n =263)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Learning Styles</td>
<td>0.78</td>
</tr>
<tr>
<td>2</td>
<td>Student Assessment</td>
<td>0.39</td>
</tr>
<tr>
<td>3</td>
<td>Teacher and His/Her Personal Characteristics</td>
<td>17.50</td>
</tr>
<tr>
<td>4</td>
<td>Resources, Props and Materials</td>
<td>9.73</td>
</tr>
<tr>
<td>5</td>
<td>Hands on Opportunities for Learning</td>
<td>12.45</td>
</tr>
<tr>
<td>6</td>
<td>Constructivist Learning-Exploration</td>
<td>26.46</td>
</tr>
<tr>
<td>7</td>
<td>Relevance to Everyday Life</td>
<td>3.89</td>
</tr>
<tr>
<td>8</td>
<td>Questioning Strategies</td>
<td>10.12</td>
</tr>
<tr>
<td>9</td>
<td>Student Engagement</td>
<td>14.79</td>
</tr>
<tr>
<td>10</td>
<td>Multi-disciplinary</td>
<td>3.89</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

These 10 axial codes for survey item 9 were then perused and verified by two researchers as they reviewed the data looking for themes representing initial selective codes. Three initial selective codes emerged and are presented, along with the percentage of responses that fell into each code, in Table 28 below.
Table 28

*Initial Selective Themes for Survey Item 9 for Research Question Four: What Do you Think You Do Well When You Are Teaching Science?*

<table>
<thead>
<tr>
<th>Theme Number</th>
<th>Initial Selective Theme</th>
<th>Percentage of Responses (n = 263)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6</td>
<td>Teacher Preparedness:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teacher/Personal Characteristics</td>
<td>17.50</td>
</tr>
<tr>
<td></td>
<td>Resources: Props and Materials</td>
<td>9.73</td>
</tr>
<tr>
<td></td>
<td><strong>Total for 4.6-Teacher Preparedness</strong></td>
<td><strong>27.23</strong></td>
</tr>
<tr>
<td>4.7</td>
<td>Instructional Method:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hands-on-Opportunities for learning</td>
<td>12.45</td>
</tr>
<tr>
<td></td>
<td>Learning Styles</td>
<td>.78</td>
</tr>
<tr>
<td></td>
<td>Constructivist Learning</td>
<td>26.46</td>
</tr>
<tr>
<td></td>
<td>Questioning Strategies</td>
<td>10.12</td>
</tr>
<tr>
<td></td>
<td>Science Relevance to Everyday Life</td>
<td>3.89</td>
</tr>
<tr>
<td></td>
<td>Multi-disciplinary Approach to Instruction</td>
<td>3.89</td>
</tr>
<tr>
<td></td>
<td>Student Assessment</td>
<td>.39</td>
</tr>
<tr>
<td></td>
<td><strong>Total for 4.7-Instructional Method</strong></td>
<td><strong>57.98</strong></td>
</tr>
<tr>
<td>4.8</td>
<td>Expected Student Outcomes:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Student Engagement</td>
<td>14.79</td>
</tr>
<tr>
<td></td>
<td><strong>Total for 4.8-Expected Student Outcomes</strong></td>
<td><strong>14.79</strong></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

More than a quarter of the responses from survey item 9 dealt with teacher preparedness. One participant noted, “[I can] create an experience they will remember.” Words such as “enthusiasm” and “enjoyment” were reported by participants as the qualities they believe are their *individual* professional and personal characteristics that help to increase
their effectiveness when they are teaching science. A few of the participants discussed the importance of resources, props and materials necessary to teach science. Many of the participants discussed various ways of engaging students, such as using instructional technology that included Smartboards and document cameras. One participant reported “I use food—things that really grab kids’ interest.”

More than half of participants’ responses dealt with the instructional methods that the participants believe assist them in teaching science well. Some participants discussed hands-on opportunities for learning. One participant reported that hands-on opportunities “encourage trial and error when proving hypothesis.” A few of the respondents indicated that being responsive to a student’s learning style was also important to them as classroom teachers of science. Many of the participants reported encouraging constructivist learning in their classrooms. As one participant shared, she can “create an environment for children to think ‘out of the box’.” Participants also suggested that the use of questioning strategies was an important component to teaching science well. As one participant stated, “asking higher level and inferential thinking questions” is important. Another participant reported that “giving students’ time to formulate their own questions about an experiment” is also important. Some of the participants discussed the importance of science being relevant to students’ everyday life.

A minority of responses to this item focused on expected student outcomes, which is of concern to teachers who want to teach science well. The participants who responded to this item cited the need to create student-centered lessons and to be responsive to individual students’ needs when they are teaching science. As one participant noted, “[I] engage my students by helping them make connections with their experiences.” Many of the
participants discussed the importance of student engagement. One participant noted that by “having a clear objective for each session,” students will be engaged in the learning process.

Survey item 10: What are some of the challenges you face when teaching science?

Again, for survey item 10, the researcher open-coded data from participants, and these 242 open codes were then categorized into seven axial codes representing patterns. The seven axial codes from the response data collected from survey item number 10, along with a percentage of responses that dealt with this code, are presented in Table 29.

Table 29

Initial Axial codes for Qualitative Data for Survey Item 10: What Are Some of the Challenges You Face when Teaching Science?

<table>
<thead>
<tr>
<th>Number of Code</th>
<th>Description of Axial Code</th>
<th>Percentage of Responses (n=242)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Time Shortage</td>
<td>35.84</td>
</tr>
<tr>
<td>2</td>
<td>Focus on State Assessments</td>
<td>1.33</td>
</tr>
<tr>
<td>3</td>
<td>Teacher and Personal Characteristics</td>
<td>5.75</td>
</tr>
<tr>
<td>4</td>
<td>Resources, Props, Materials, Curriculum</td>
<td>33.19</td>
</tr>
<tr>
<td>5</td>
<td>Inappropriate Science Curriculum</td>
<td>14.16</td>
</tr>
<tr>
<td>6</td>
<td>Lack of Teacher Science Knowledge</td>
<td>8.85</td>
</tr>
<tr>
<td>7</td>
<td>Professional Development Needs</td>
<td>0.88</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

These seven axial codes for survey item 10 were then perused by the researcher as she reviewed the data looking for themes representing initial selective codes. Three initial
selective codes emerged and are presented, along with the percentage of responses that fell into each code, in Table 30 below.

Table 30

*Initial Selective Themes for Survey Item 10 for Research Question Four: What Are Some of the Challenges You Face when Teaching Science?*

<table>
<thead>
<tr>
<th>Theme Number</th>
<th>Initial Selective Theme</th>
<th>Percentage of Responses (n = 242)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9</td>
<td>Lack of Time and Resources:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time Shortage</td>
<td>35.84</td>
</tr>
<tr>
<td></td>
<td>Professional Development Needs</td>
<td>.88</td>
</tr>
<tr>
<td></td>
<td>Resources, Props, and Materials Needs</td>
<td>33.19</td>
</tr>
<tr>
<td></td>
<td>Total for 4.9-Lack of Time and Resources</td>
<td>66.91</td>
</tr>
<tr>
<td>4.10</td>
<td>Inappropriate Curriculum and Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inappropriate Science Curriculum</td>
<td>14.16</td>
</tr>
<tr>
<td></td>
<td>Focus on State Assessments</td>
<td>1.33</td>
</tr>
<tr>
<td></td>
<td>Total for 4.10-Inappropriate Curriculum and Assessment</td>
<td>15.49</td>
</tr>
<tr>
<td>4.11</td>
<td>Teacher Qualities:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of Teacher Knowledge Regarding Science</td>
<td>8.85</td>
</tr>
<tr>
<td></td>
<td>Lack of Teacher Efficacy In Teaching Science</td>
<td>5.75</td>
</tr>
<tr>
<td></td>
<td>Total for 4.11-Teacher Qualities</td>
<td>14.60</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

Almost two-thirds of responses from survey item 10 dealt with teachers’ beliefs that they lack time and resources to teach science well. As one participant shared, “[There is a] lack of materials; outdated materials; [and] time to teach the concepts across the school day.” Some participants addressed the lack of time during the school day more directly, as it was a
deterrent to completing science experiments and activities. One participant noted its importance as “time to let children experiment; discuss; [and then to] react.” Others responded to the challenge of time constraints as a matter of establishing priorities. As one participant reported, “I think every subject area is getting squeezed nowadays, but none perhaps as much as science. I think the challenge is giving the students a full and rich science experience in a shorter window of time.” Some of the respondents discussed the lack of appropriate resources, props and materials more specifically, detailing the lack of science kits and replacement materials as well as classrooms ill-equipped with a lack of science-friendly activity areas and amenities such as sinks and access to the out-of-doors.

Some responses focused on the lack of appropriate curriculum and assessment tools. Some participants reported that the science curricula were outdated, not engaging to students, and not user-friendly. “[The] curriculum seems vague,” stated one participant. A few participants noted that part of the problem lies in the focus on state assessments. As one participant admitted, “[I] only teach science in the fall till Christmas. Then [I teach science] after March, because of test prep [state assessment] (CMT).”

Some responses dealt with participants’ beliefs that they lacked important teacher qualities which would enable them to be more successful in their teaching of science. Some of the participants identified a lack of teacher knowledge regarding science, as one participant stated, “My knowledge of science is limited.” Another participant reported that she found it “difficult presenting abstract concepts.” And still another stated, “It is sometimes hard to explain concepts with age appropriate language. “Other participants discussed their lack of science efficacy when teaching science activities. As one participant
explained, “I don’t consider myself to be a ‘science person’.” Another stated that science was “not [my] strongest subject.”

**Summary of qualitative data.** In conclusion, participating teachers expressed a variety of beliefs that responded to research questions three and four. Participating elementary school teachers discussed the inquiry-based practices they used in their classrooms based on their beliefs about inquiry. These participants also shared their specific beliefs about developing self-efficacy and its impact on inquiry beliefs. And finally, the participants shared the specific challenges they face when attempting to implement inquiry-based science practices in their elementary school classrooms.

To further explore the relationships among these qualitative findings, the researcher collapsed initial selective themes across research questions; these are presented in Table 31. The final selective themes are organized into four categories: (a) teachers’ beliefs about what inquiry is; (b) specific inquiry-based practices that teachers use in their classrooms; (c) specific beliefs teachers hold about how to teach science well; and (d) specific challenges teachers’ believe that they face when teaching science well in the elementary classroom.
Table 31

*Final Selective Themes for Qualitative Data*

<table>
<thead>
<tr>
<th>Initial Selective Theme Number</th>
<th>Initial Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Selective Theme One: Teachers hold specific beliefs about what inquiry is in the elementary science classroom:</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Teachers believe that inquiry involves fostering student interest and engaging the learner.</td>
</tr>
<tr>
<td>3.2</td>
<td>Teachers believe that inquiry is about student-centered active learning.</td>
</tr>
<tr>
<td>4.7</td>
<td>Teachers believe that inquiry is about differentiating for the learner.</td>
</tr>
<tr>
<td>3.3</td>
<td>Teachers believe that they may use specific curriculum-based strategies (e.g., challenging content and higher-order thinking student skills) to encourage inquiry.</td>
</tr>
<tr>
<td>Final Selective Theme Two: Teachers believe that they use specific inquiry-based practices in the elementary science classroom:</td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>Teachers believe that they use inductive learning in their elementary science teaching.</td>
</tr>
<tr>
<td>4.8</td>
<td>Teachers believe that they engage students.</td>
</tr>
<tr>
<td>4.2</td>
<td>Teachers believe that they use a variety of specific pedagogical strategies to differentiate for and engage students.</td>
</tr>
<tr>
<td>4.3</td>
<td>Teachers believe that specific teacher characteristics, experiences and knowledge are important to teach science well.</td>
</tr>
</tbody>
</table>
Table 31 (continued)

*Final Selective Themes for Qualitative Data*

<table>
<thead>
<tr>
<th>Initial Selective Theme Number</th>
<th>Initial Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4</td>
<td>Teachers believe that it is important to explore science to teach science well.</td>
</tr>
<tr>
<td>4.5</td>
<td>Teachers believe that it is important to be life-long science learners to teach science well.</td>
</tr>
<tr>
<td>4.6</td>
<td>Teachers believe that it is important to be resourceful in order to teach science well.</td>
</tr>
</tbody>
</table>

Final Selective Theme Four: Teachers believe that there are specific barriers to teaching science well in the elementary science classroom.

| 4.11                           | Teachers believe that they sometimes do not have enough content knowledge and efficacy regarding how to teach science well. |
| 4.10                           | Teachers believe that they do not always have access to appropriate curriculum and assessment when teaching science. |
| 4.9                            | Teachers believe that a lack of time, training, and other resources present barriers to teaching science well. |
Teachers acknowledged that, to teach science well, it is imperative to foster student interest in science learning, a key element in teaching science as inquiry. They offered examples of specific student activities such as journal writing; regardless of the teacher-based strategies they mentioned, they suggested that the focus should be on a student-centered active learning model. They suggested that it was important to differentiate for the learner when teaching science. When discussing curriculum-based strategies for structuring science activities and the acquisition of scientific knowledge, participants stated that using challenging science content and promoting student questioning were important.

Participants reported that they used a variety of inquiry-based practices that they believed engage students. They focused on inductive learning. Teachers reported a feeling of satisfaction for a job well done when their students were engaged in learning. Teachers also pointed to the need for specific pedagogical strategies that would enable them to differentiate science instruction and offer all students the opportunity for science engagement.

Participants noted the complexity of developing their ability to teach science well. They believed that the key to developing the inquiry-based strategies discussed above are specific personal and professional characteristics, such as being open to new and varied experiences and approaching the teaching of science as more than just another curriculum topic. They suggested that the goal is to become life-long science learners, pursuing scientific experiences and knowledge, thereby developing deeper scientific understandings which may be shared more easily with students; they also noted that developing this life-long love of science requires science exploration, both as an educator and as an individual, both in and outside of the classroom. Finally, they noted that good science teaching is helped by
resourcefulness, or capitalizing on what is available, such as materials, experiences, integrated curriculum, and community resources.

Participants reported that they faced specific barriers when attempting to develop their ability to teach science well. They raised concerns such as the lack of teacher science content knowledge, appropriate science curriculum and assessment materials, time to teach science, resources, and the amount and appropriateness of professional development opportunities in elementary science education.

**Triangulation of Quantitative Data and Qualitative Selective Themes**

The researcher analyzed the qualitative data as it relates to the quantitative research questions and their results. Table 32 displays the results of these analyses.

The researcher further investigated the second finding for research question four that indicated that of all the grade levels, specifically, fifth grade teachers, demonstrated increased efficacy on the STEBI-A. A follow-up phone call with the building administrators from seven of the sampled schools (one school was K-4 and did not necessitate a follow-up call) yielded interesting information regarding the teaching of science at the fifth grade level.

The administrators concurred that each of the fifth grade teachers from the current study ($n = 18$) had been assigned content-specific curriculum such as Social Studies, Science, and Math due to a similar range of qualifications which included an interest in science or outside experiences such as a summer camp nature counselor position. The administrators explained that this is a common practice. When asked how the fifth grade teachers are assigned their specific subject area, the majority of administrators explained that those teachers expressing a specific interest in a curriculum area are encouraged to teach that subject. Often, teachers will continue to teach within a curriculum area for years. However,
one administrator shared that her fifth grade teachers do rotate subject areas yearly. The teachers at her school explore a specific subject area each year, but they maintain an overall knowledge of the subject area for future teaching assignments.

Additionally, the administrators reported that, in both states in which these schools reside, statewide assessments are mandated for fifth grade students, requiring a sophisticated approach to science instruction as well as a direct alignment with core state science standards. They explained that their fifth grade teachers are expected to demonstrate increased science scores for their students. Therefore, fifth grade teachers may be more focused and purposeful in their science teaching based on curricular and assessment demands and responsibilities, compared to teachers from the other grade levels.
Table 32

*Triangulation of Research Questions One and Two with Qualitative Initial Selective Themes from Research Questions Three and Four*

<table>
<thead>
<tr>
<th>Quantitative Results</th>
<th>Qualitative Theme</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Question One: Three or more elective undergraduate science courses predicted science self-efficacy.</td>
<td>4.3—Specific Teacher Characteristics, Experiences, and Knowledge</td>
<td>Teachers believed that opportunities to develop content knowledge and skills are important for effective science teaching.</td>
</tr>
<tr>
<td></td>
<td>4.3—Exploration of Science</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.5—Life-long Science Learners</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.6—Teacher Preparedness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.9—Lack of Time and Resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.11—Teacher Qualities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1—Fostering Student Interest</td>
<td>Fifth-grade teachers were pre-selected for their knowledge, experiences, and qualities to teach science curriculum.</td>
</tr>
<tr>
<td></td>
<td>3.2—Teacher-based Strategies that Encourage Student Questioning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3—Curriculum-based Strategies that Encourage Student Questioning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.1—Pedagogical Concerns, Inductive Learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.2—Pedagogical Concerns, Specific Strategies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.7—Instructional Method</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.8—Student Outcomes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.3—Specific Teacher Characteristics, Experiences, and Knowledge</td>
<td>Teachers believed that it was important to learn to do a variety of pedagogical strategies to promote students’ questioning.</td>
</tr>
<tr>
<td></td>
<td>4.5—Life-long Science Learners</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.6—Teacher Preparedness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.9—Lack of Time and Resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.11—Teacher Qualities</td>
<td></td>
</tr>
</tbody>
</table>

Dichotomous coding revealed that fifth grade teachers demonstrated increased self-efficacy.

Teachers believed that it was necessary to develop themselves as life-long science learners to teach science well (and promote students’ questioning).
Conclusion

In this chapter, the researcher presented the data analyses performed to investigate the nature of the sample and the results. The preliminary analyses included a review of the methods used for data screening and cleaning. Sample characteristics and research designs were also discussed. The quantitative methods used to analyze research questions one and two were presented, and qualitative procedures used to address research questions three and four were described. The research concluded with a triangulation of the quantitative data with the qualitative themes.

For research question one, two of the predictors, three or more additional undergraduate elective science courses and grade level, specifically for fifth grade teachers, were found to be significant predictors of increased science self-efficacy. For question two, higher levels of science self-efficacy were found to be significant predictors of increased questioning and thinking practices of elementary school teachers teaching science. For research questions three and four, the final selective themes that the participants expressed may be summarized as follows: (a) specific instructional practices that are inquiry-based are useful in elementary science classrooms; (b) specific inquiry-based science beliefs are held by elementary school classroom teachers; (c) specific beliefs about developing science self-efficacy are held by elementary school classroom teachers; and (d) challenges exist in implementing inquiry-based science practices in elementary school classrooms. The next chapter will further discuss the relationship between the quantitative and qualitative findings, as well as implications of these findings, and will also present future research opportunities that have emerged from this study.
CHAPTER FIVE: SUMMARY AND CONCLUSIONS

This chapter contains six sections that elaborate on the current research. The research problem and questions that guide the study are summarized in the Summary of the Study. In the Procedures Section, research procedures are organized by individual research questions, analysis, and synthesis of procedures used to analyze data. The Findings Section presents the findings of the study, which are then linked to the review of the literature in a Comparison and Contrast of Findings. The Implications for Educators Section follows, which offers suggestions to educators and instructional leaders based on these findings. This is followed by Suggestions for Future Research. The Limitations Section expands upon the issues that surfaced throughout the study and the manner in which the researcher dealt with these challenges.

Summary of the Study

The initial problem addressed in the current research focused on understanding the relationship and the impact that certain factors have in predicting self-efficacy for kindergarten through fifth grade elementary school classroom teachers who teach science. Science self-efficacy was then selected as a possible predictor of the frequency of teachers’ higher-level questioning practices.

The researcher utilized survey methodology to explore teachers’ beliefs regarding self-efficacy, the instructional methods that they choose, as well as the importance of specific questioning strategies that they utilize in elementary school science instruction. The research used a purposeful sample of convenience consisting of 143 full-time kindergarten through fifth grade elementary school classroom teachers from eight elementary schools located in six school districts in the northeast. Data were collected using survey methodology; the instrument was a paper survey entitled the Classroom Science Instruction Survey (CSIS).
The CSIS contained four sections: (a) a set of 6 demographic items, (b) 5 open-ended response items, (c) 13 closed-ended response items from the Science Teaching Efficacy Belief Instrument (STEBI – A, Personal Science Teaching Efficacy Beliefs subscale only) (Riggs & Enochs, 1990), and (d) 5 closed-ended response items from the National Research Center on the Gifted and Talented (NRC/GT) Classroom Practices, Questioning and Thinking subscale (Archambault et al., 1993). The CSIS surveys were administered at faculty staff meetings.

The following research questions guided this study:

1. To what extent and in what manner did the internal factor (gender) and external factors (grade level taught, years of experience, number of elective undergraduate science courses, highest degree earned, science degree-yes or no) predict self-efficacy in science teaching for practicing elementary school teachers who teach science in grades K-5?

2. To what extent and in what manner did self-efficacy predict the (self-reported) occurrence of higher order questions for practicing classroom teachers who teach science in grades K-5?

3. How did practicing elementary school teachers view the importance of questioning skills in science instruction?

4. What instructional methods did practicing teachers in grades K-5 prefer to use when they taught elementary school science? Why?

A convergent parallel mixed method research design combined quantitative and qualitative approaches necessary for a more complete understanding of teachers’ beliefs. A quantitative correlational research design was most appropriate for research questions one
and two. For research questions three and four, a general qualitative research design was most appropriate to analyze participants’ responses from the open-ended items.

The researcher utilized multiple linear regression to analyze research question one. Predictor variables from the demographic items of the CSIS survey (gender, grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, science degree-yes or no) were used to predict participants’ mean sub-scale scores on the STEBI-A (the criterion variable). For research question two, a simple linear regression was used to determine whether mean self-efficacy scores on the STEBI-A (the predictor variable) would explain the variance in the mean questioning and thinking subscale scores on the CPS Survey (the criterion variable). Frequencies, descriptive statistics of means, and standard deviations were also examined for both research questions one and two. Research questions three and four were analyzed using qualitative methods that utilized three levels of coding techniques—open coding, axial coding, and selective coding, which were applied to the data, as suggested by Strauss and Corbin (1998).

Findings

This section presents the results from the data analyses performed in Chapter Four for each of the four research questions.

Research Question One

For research question one, the researcher chose a standard multiple linear regression method of analysis, meaning that all predictors were entered into the model in one step. The predictor variables were gender, number of years of experience teaching science, grade level taught, number of elective undergraduate science courses, highest degree earned, and science degree (yes or no). Together, the variables in the model explained 21.7% of the variation in
teachers’ self-efficacy. The model was significant, $F (13,141) = 3.78, p < .001$. $f^2 = .26$ was small (Meyers et al., 2006). Dichotomous codes representing three or more science courses ($p < .05$), five or more science courses ($p < .001$) and grade level five teachers ($p < .05$) were significant predictors of science self-efficacy.

**Research Question Two**

To analyze research question two, the researcher used a simple linear regression. The predictor variable for research question two was the mean subscale score of the STEBI-A, and the criterion variable consisted of the mean subscale score for the questioning and thinking section on the CPS. The model was significant, $F (1, 139) = 9.806, p = .002$. $f^2 = .06$ was trivial (Meyers et. al., 2006), with 6% of the variance for the mean of the CPS predicted by the predictor variable, scores on the STEBI-A. Self-efficacy was found to be a significant predictor of increased questioning and thinking skills in elementary classroom science instruction. The specific questioning and thinking skills included in the CPS survey were: (a) encouraging thinking skills in the regular curriculum; (b) encouraging open-ended questions; (c) encouraging higher order questioning skills; and (d) encouraging student participation in discussions. To summarize, as the mean scores on the STEBI-A increased, the scores on the CPS increased.

**Research Question Three**

For research question three, it is important to begin with noting that participants reported frequently utilizing questioning strategies in their classrooms. In the quantitative analysis of research question two, participants scored fairly highly on the CPS ($M = 4.39$) on a 6 - point Likert scale, indicating that most participants reported that they utilized questioning strategies at least daily. Final selective themes suggested that teachers believed
that specific curriculum-based strategies which employ challenging content and higher-order thinking student skills result in student questioning. Teachers also believed that it is important to foster student interest in order to generate student questions. And finally, teachers believed that specific teacher–based strategies that encourage student-centered active learning resulted in student questioning.

**Research Question Four**

Findings for research question four suggested that teachers held specific beliefs about instructional practice, and they described the importance of using specific inquiry-based methods for the elementary science classroom. They believed that optimal gains occur when students learn inductively and are engaged in classroom science activities. They suggested that these inquiry-based methods both differentiate learning and engage students. Teachers also reported feeling successful when this type of learning occurs.

Teachers expressed specific beliefs about how they might develop their own self-efficacy in the elementary-school science classroom. Teachers believed that to develop self-efficacy, it is important to explore science themselves, with the goal of becoming life-long science learners. Teachers also believed that specific teacher characteristics, experiences, and science content knowledge were important in developing these strategies. They also understood that it was important to be resourceful and utilize time, resources and materials well.

Most importantly as it relates to this study, teachers reported a lack of teacher content knowledge and efficacy when teaching science. They believed that there were specific barriers to developing self-efficacy in the elementary school science classroom. Specifically, they described the lack of lack of time, training, and resources. They also reported having inappropriate curriculum and assessment materials.
Comparison and Contrast of Findings

The first part of the literature review identified the rationale for this study, discussing the declining trend in U.S. students’ achievement levels in mathematics and science on the TIMSS (Gonzales, 2009). Some researchers (Enochs & Riggs, 1990; Metz, 2008, 2011; Spooner & Simpson, 1979; Stevens & Wenner, 1996) have suggested that efforts in the U.S. to improve science education have overly emphasized middle school and high school reforms, but have neglected elementary school science. According to Duschl (1990), elementary-school teachers may be considered as agents of change in this reform endeavor. However, Metz (2009) pointed to the complexity of the situation by noting that elementary-school teachers are faced with the frustration of being both the targets and agents of change simultaneously.

Since the days of the great Greek philosophers, many educational reformers and theorists (Bybee & DeBoer, 1993; Dewey, 1910; Haury & Rillero, 1992; Maker, 1982; Mastropieri & Scruggs, 1994) have presented research calling for inquiry-based instructional practices in younger elementary school students’ science learning experiences. In the current research, teachers in the sample recognized the need and importance of practicing inquiry. In fact, inquiry-based science is promoted by all national organizations such as the AAAS (1993), NRC (1996, 2000), NSF (2005), the NSRC (2011); and the NSTA (2011).

Dana et al. (1997) have noted that teacher behaviors, both in and out of school, promote inquiry-based learning. Researchers have suggested that teacher behaviors may best be understood by focusing on teachers’ ideas and opinions about self-efficacy and the manner in which these ideas and opinions evolve. In the current study, teachers shared specific beliefs about developing self-efficacy in the elementary science classroom, noting
that good teachers are life-long science learners, both in and out of the classroom. They point to this teacher characteristic as one that is necessary if one hopes to develop science self-efficacy.

Researchers (Abelson, 1979; Bandura, 1986; Nespor, 1987; Pajares, 1992; Richardson, 1996) have found that teachers form self-perpetuating beliefs early in their careers that will affect instructional behavior, despite evidence and experiences to the contrary. Researchers (Akerson et al., 2007; Avraamidou & Zembal-Saul, 2010; Shulman, 1986) have also found that elementary school science teachers’ content (subject) knowledge, pedagogy knowledge, Pedagogical Content Knowledge (PCK) (Shulman, 1986) and their knowledge about the nature of science (NOS) (NSTA, 2011) play vital roles in their instructional practices. In the qualitative data collected for this study, teachers spoke of these early science experiences and knowledge which helped them to formulate their current instructional teaching methods.

However, not all teachers reported satisfaction with their ability to teach science. In fact, some reported feeling inadequate regarding their current instructional science teaching methods. This diminished level of science self-efficacy was described specifically by some teachers, who reported frustration in responding to students, a frustration that they believed was due to a lack of their own science content knowledge. It is interesting to note that the quantitative findings in the study support this notion, indicating that science self-efficacy for participants in the sample increased with the number of elective science (three or more) courses taken as undergraduate students.

The second part of the literature review focused on the factors associated with increased science self-efficacy and the impact these factors exert on acquiring and
maintaining science self-efficacy over the course of one’s teaching career. The literature review revealed that the internal factor of gender, and the external factors of number of elective undergraduate science courses, years of teaching experience, grade level taught, highest level of degree earned, and type of college degree (science vs. non-science) may impact how self-efficacious a teacher may feel about teaching science.

Previous gender researchers (Bleeker & Jacobs, 2004; Eccles, 1989, 1994; Halpern et al., 2007; Riggs, 1991) have found that gender plays a role in students’ self-efficacy in the classroom and may therefore also play a role in the selection of science careers. However, from the current study’s list of predictors for the regression model, gender was not found to have an impact on self-efficacy. It is possible that this lack of significance is due to the fact that female teachers ($n = 133$), far outnumbered male teachers in the sample ($n = 10$); without a sufficiently large sample of male teachers, it becomes difficult to uncover variation between the sexes.

In the current study, taking three or more elective undergraduate science courses was associated with increased science self-efficacy. Eschach (2003) has suggested that colleges and universities have increased the number of traditional mathematics and science courses offered to education students for this very reason. However, Shulman’s (1986) research has emphasized that offering science content without employing best instructional methods does not always impact students’ science learning in a positive way. The current study offers limited insight on the variety of college courses that best prepare practicing elementary teachers, as only a few teachers in the current study were specific as to the particular science topics about which they felt unsure when teaching science.
Researchers (Davis & Smithey, 2009; Kumar & Morris, 2005; Watters & Ginns, 2000) have suggested that specific elements of both elective and core undergraduate science education courses for pre-service teachers are most beneficial if they provide opportunities for prospective teachers to learn how to: (a) engage students, (b) organize instruction; (c) understand their own and future students’ developing Pedagogical Content Knowledge (PCK); (d) develop lesson plans that are more functional in real-life classroom situations; (e) provide problem–based learning experiences that feature collaborative learning and reflective journal writing; and (f) increase science content knowledge. It is interesting to note that teachers in the study identified similar, if not the same, items as specific challenges to teaching elementary inquiry-based science. These teachers also reported a lack of district support and professional training opportunities which, if acquired, would better enable them to achieve the goals specified above.

A variety of personal and environmental factors influence teachers’ lifelong self-efficacy for science instruction and this self-efficacy may or may not be associated with increased years of teaching classroom science. Bandura (1997) found that self-efficacy wanes for some mid-to-late career stage workers as they may choose to slow down and re-evaluate their goals, and many participants in the sample for this current study were mid-career teachers in that the mean number of years that participants reported teaching was 13.58. However, it is interesting to note that teachers in the sample with more years of classroom teaching experience did not demonstrate significantly higher self-efficacy. This might be due to Bandura’s (1997) research which found that some working environments hinder self-efficacy, but the current research did not specifically address this issue.
Although limited research was available regarding specific grade levels associated with increased or decreased self-efficacy in practicing elementary school classroom science teachers, grade level was found to be a significant predictor of self-efficacy. Specifically, the dichotomous code that was used for teachers at the fifth grade level \( (n = 18, 12.6\%) \) was found to be a significant predictor of science self-efficacy. In searching for a deeper understanding of this finding, the researcher contacted the administrators from the sampled schools. All fifth grade teachers from the current study had been assigned content-specific curriculum such as Social Studies, Science, and Math due to a similar range of qualifications which included an interest in science or outside experiences such as a summer camp nature counselor position. The administrators explained that this is a common practice. Of the 18 teachers in the study, none had reported that they did not teach science. When asked how the fifth grade teachers are assigned their specific subject area, the majority of administrators explained that those teachers expressing a specific interest in a curriculum area are encouraged to teach that subject. The final decision is made by the building principal, although in one district, it was explained that the district superintendent makes the decision. Often, teachers will continue to teach within a curriculum area for years. However, one administrator shared that her fifth grade teachers do rotate subject areas yearly. The teachers at her school explore a specific subject area each year, but they maintain an overall knowledge of the subject area for future teaching assignments.

Additionally, in a follow-up discussion with each school, the building administrators also reported that fifth grade statewide assessments in both states require a sophisticated approach to science instruction as well as a direct alignment with core state science standards. They explained that their fifth grade teachers are expected to demonstrate
increased science scores for their students. Therefore, this additional information would seem to indicate that the fifth grade teachers are more focused and purposeful in their science teaching based on curricular and assessment demands and responsibilities as compared to the teachers from the other grade levels.

**Implications for Educators**

The current research offers educators a number of implications for practice (Table 33). The first of the quantitative results from the current study indicate that practicing elementary school classroom science teachers who had taken three or more elective undergraduate science courses demonstrated increased science self-efficacy. Therefore, college administrators and education faculty would do well to address this issue when formulating academic program schedules for those majoring in elementary education. Additional science content courses, possibly designed specifically for elementary education majors might be included. Requiring additional science teaching methods courses that are structured with more content-based science information, with the hope of providing undergraduate students more access to science-content knowledge, may also prove useful. If colleges require that undergraduate teaching candidates enroll in more in-depth science-content courses, then it follows that these students will be better prepared to understand content, which could result in their feeling better prepared to tackle the challenges of the elementary school science classroom.

Secondary school administrators must help prepare future undergraduate students with opportunities and guidance to succeed in higher level science courses. For practicing elementary school classroom teachers, offering ongoing non-credit course work affords them an alternative to credit-bearing programs, while still providing them with access to science
content curriculum. The agencies that provide this programming, such as teacher centers and teacher unions, might include these professional development offerings that focus on science-content knowledge in workshop formats.

Additional quantitative results from the current study indicate that being a fifth grade teacher was associated with increased self-efficacy. Based on additional research conducted by the researcher regarding this finding, district and school administrators have encouraged curriculum alignment and fostered teacher interest in fifth grade science teaching. It would be interesting, however, for administrators to borrow some of these practices such as the careful alignment of individual school science curriculum with core state science standards so that all teachers have a clearer idea of what they should be teaching. Team science leaders could be selected on the basis of particular science interests, experience and willingness to design age-appropriate science activities for each grade level. By rotating this position, building administrators would enable all teachers to experience an increased range of science activities that would benefit students’ and teachers’ science learning.

Teachers’ instructional science self-efficacy was found to predict the increased use of questioning and thinking skills in elementary classroom science instruction. In other words, when teachers felt comfortable about their ability to teach science, they were more likely to encourage students’ questions in science. In their qualitative responses, some teachers reported a lack of understanding of science content and suggested that they were hesitant to encourage student questioning if they didn’t know the answers themselves. This finding may prove helpful to administrators in curriculum development. Professional development might assist teachers by providing opportunities for increased science-content knowledge and science instructional practices, thereby offering teachers more authentic training experiences.
Mentoring may also be a useful tool for enabling skilled classroom science teachers to assist colleagues in developing increased science self-efficacy. Principals might arrange for classroom observations and common planning time to provide for mentors and mentees to share best practices in science instruction.

Overwhelmingly, teachers noted that good teachers teach science well when they enact more inquiry-based practices that engage students and encourage active inductive learning. These practices included using more hands-on and developmentally appropriate science curricula and more hands-on science materials that are easier to access, conducting better student assessments, and providing students with equal time (compared with other subjects) for science instruction in daily classroom schedules. Some teachers reported that they currently teach science using inquiry-based methods. However, it was interesting to note that some teachers also described a specific teacher-directed instructional activity (such as a whole group demonstration), defining it as a good hands-on science activity for students.

There appeared to be some confusion as to the definition of inquiry-based practice. Again, targeted professional development with the inclusion of a mentoring system for collegial support on an on-going basis would help teachers refine their instructional practices for more optimal inductive learning experiences that are inquiry-based.

Teachers believed that exploring the world of science helps them to develop their own self-efficacy. Teachers noted that field trips to nature centers and science increased their science learning. Partnerships might be therefore encouraged between school districts and community science organizations that would enable both teachers and students to expand their scientific content knowledge and benefit all in the elementary learning community.

Teachers also reflected on the importance of being life-long science learners in both their
personal and professional lives, noting that this helped them to become more self-efficacious. School districts and community organizations might explore STEM partnerships for teachers and their families that offer opportunities for participation in aquarium programs, whale watches, wilderness experiences, environmental and nature centers, corporate research and development think tanks, local universities, engineering programs, industrial centers, and public museums.

Resourcefulness was also listed as an important attribute of self-efficacious classroom science teachers. Accordingly, administrators might arrange for the procurement and storage of a wide range of science materials. Grant opportunities for procuring materials could be investigated by school personnel; teachers could be supported in this effort by affording them release time to investigate and write grants. Science curriculum developers and elementary and secondary science coordinators might pool their resources for the procurement of supplies, and approach various industrial corporations and universities for discounted supplies and materials. The educational implications for the study are summarized in Table 33.
### Table 33

**Summary of Educational Implications**

<table>
<thead>
<tr>
<th>Finding</th>
<th>Implications for Educators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants with three or more elective science courses as an</td>
<td>College administrators—accommodate additional science content courses in elementary education academic program schedules.</td>
</tr>
<tr>
<td>undergraduate felt more self-efficacious about teaching elementary</td>
<td>College administrators and professors—design content-heavy courses specifically for elementary education undergraduate students.</td>
</tr>
<tr>
<td>science.</td>
<td>Secondary school administrators—provide entry level college students with necessary credentials, guidance and self-efficacy to successfully fulfill undergraduate science coursework.</td>
</tr>
<tr>
<td></td>
<td>Teacher centers and unions—provide professional development offerings that focus on science-content knowledge in their teacher training workshops.</td>
</tr>
<tr>
<td>Teachers at the fifth grade level felt more self-efficacious about</td>
<td>School administrators and building principals—encourage curriculum alignment with state-wide /district core science standards and foster individual teacher interest in science teaching.</td>
</tr>
<tr>
<td>teaching elementary science.</td>
<td>Elementary principals and curriculum coordinators—provide professional development opportunities in elementary school science that are more experiential and hands-on, with opportunities for teachers to practice questioning and thinking skills in more authentic settings.</td>
</tr>
<tr>
<td>Self-efficacy was found to be a significant predictor of increased</td>
<td>District and elementary school administrators – provide science mentors /master-level science teachers to collaborate and provide collegial support to those teachers lacking science self-efficacy and science-teaching experience.</td>
</tr>
<tr>
<td>questioning and thinking skills in elementary classroom science.</td>
<td></td>
</tr>
</tbody>
</table>
Table 33 (continued)

*Summary of Educational Implications*

<table>
<thead>
<tr>
<th>Finding</th>
<th>Implications for Educators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers use specific inquiry-based practices in the elementary science classroom.</td>
<td>District administrators and curriculum coordinators—establish criteria for district-wide elementary school science curricula that include more inquiry-based hands-on and developmentally appropriate science goals, objectives and activities.</td>
</tr>
<tr>
<td></td>
<td>Principals and curriculum coordinators – provide teachers with hands-on science resources.</td>
</tr>
<tr>
<td></td>
<td>District administrators, principals, and curriculum coordinators—provide appropriate formative and summative science assessments.</td>
</tr>
<tr>
<td></td>
<td>Principals—allot an appropriate amount of time for science instruction in daily classroom schedules so that it is equalized with other academic subjects.</td>
</tr>
<tr>
<td>Teachers hold specific beliefs about inquiry in the elementary science classroom.</td>
<td>District administrators, principals, and curriculum coordinators—provide on-going professional development that offers teachers science mentoring and mentee opportunities that focus on inquiry-based practice.</td>
</tr>
<tr>
<td></td>
<td>District administrators, principals, and curriculum coordinators—provide professional development opportunities in inquiry-based elementary school science instruction that might help define and refine teachers’ instructional practices for more optimal inductive learning experiences.</td>
</tr>
</tbody>
</table>
Table 33 (continued)

Summary of Educational Implications

<table>
<thead>
<tr>
<th>Finding</th>
<th>Implications for Educators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers hold specific beliefs about developing self-efficacy in the</td>
<td>District administrators and principals — provide funding for active science educational experiences such as field trips to nature centers and science museums for both teachers and students.</td>
</tr>
<tr>
<td>elementary science classroom.</td>
<td>District administrators, district educational foundations, parent-teacher organizations - develop working relationships with community organizations and industry to benefit both teachers and students to expand their scientific content knowledge.</td>
</tr>
<tr>
<td></td>
<td>District administrators, principals, and curriculum coordinators - provide multidisciplinary opportunities for science exploration with other disciplines.</td>
</tr>
<tr>
<td></td>
<td>District administrators, principals, and curriculum coordinators - provide specific school-wide plans for storage, location, and procurement of science materials and instruction for primary-aged children and their needs.</td>
</tr>
<tr>
<td>Teachers believe that there are specific barriers to inquiry practices</td>
<td>Principals, curriculum coordinator, and faculty committees – provide opportunities for an open dialogue with teachers to discuss the challenges to inquiry-based instructional practices, including teacher content knowledge; science self-efficacy; appropriate curriculum and assessment; time; and science instructional training.</td>
</tr>
<tr>
<td>in the classroom in the elementary science classroom.</td>
<td></td>
</tr>
</tbody>
</table>

Suggestions for Future Research

Although the findings from the current study indicated that fifth grade teachers demonstrated an increased self-efficacy about teaching science, grade level itself needs to be more carefully explored. In a follow-up discussion by phone, administrators from the
sampled schools reported that demands on fifth grade teachers (such as summative assessments) produced a curriculum which was highly aligned with standards, and necessary for increased science achievement scores. Administrators described a process in which the most interested (and possibly talented) teachers taught science at the fifth grade level. Future research could be conducted on the impact on teachers’ self-efficacy of rotating science teachers annually, as opposed to allowing only those teachers with talents and interests in science to teach. This practice may also have an impact on other domains, in that teachers in the study expressed an interest in connecting science to other disciplines. If teachers have been exposed to other content areas, they may be empowered to make those connections.

Additionally, future research could explore the types of undergraduate science electives that are appropriate for elementary education undergraduate students. More studies are required to identify the specific combinations of high school and college courses, such as Biology, Chemistry, Physics, or Engineering, and how they could relate to development of self-efficacy in elementary science teachers. Waters and Ginns (1995) found that science experiences specifically at the high school level helped to explain some of the development of teachers’ scientific beliefs and attitudes. A qualitative study utilizing personal interviews with school administrators, curriculum leaders, and practicing teachers could help to identify in which specific areas of the science curriculum participants would like to see additional coursework.

It may also be beneficial to understand, for the purpose of increasing teachers’ self-efficacy and inquiry-based instruction, the best mode of instruction to use in these science-content courses: hands-on, lecture-based, or a combination of both. Pre-service elementary school teachers of science will require these inquiry skills in their future classrooms.
Early research by Shulman (1986) found that PCK plays an integral role in how science instruction is delivered to students, thereby impacting retention and application, so research into how to offer teachers’ opportunities to develop PCK in these undergraduate science courses would also be beneficial. Kumar and Morris (2005) have previously found that improving science knowledge in isolation, without improving pedagogical skills, may not be the answer to developing teachers’ scientific understanding. Further research is also needed into which experiences help practicing teachers continue to develop PCK for scientific inquiry, emphasizing evidence and explanation. And finally, large scale and longitudinal studies are needed to explore the specific experiences necessary for becoming life-long science learners for science teachers who must develop and maintain science self-efficacy throughout their professional careers.

Teachers in the study listed a variety of barriers to delivering inquiry-based science practices in their elementary school classrooms. These included lack of time, training, and resources to teach science effectively. Continuing research into these areas would prove beneficial, as schools are faced with ever-increasing demands but lack of funding to meet the expenses at hand. These suggestions for future researchers are summarized in Table 34.
Table 34

Summary of Implications for Future Research

<table>
<thead>
<tr>
<th>Finding</th>
<th>Implications for Researchers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers at the fifth grade level felt more self-efficacious about teaching elementary science</td>
<td>Educational researchers – conduct research that looks at the impact rotating science teaching responsibilities has on science self-efficacy</td>
</tr>
<tr>
<td>Participants with three or more elective science courses as an undergraduate felt more self-efficacious about teaching</td>
<td>Educational researchers – conduct research that helps identify specific combinations of high school and college courses, such as Biology, Chemistry, Physics, or Engineering, which help to develop science self-efficacy for elementary school teachers in their design and delivery of elementary school science curricula.</td>
</tr>
<tr>
<td></td>
<td>Educational researchers – conduct research that helps identify the specific areas of the science curriculum that benefits from additional earlier undergraduate science coursework.</td>
</tr>
<tr>
<td></td>
<td>Educational researchers – conduct research to help identify the best instructional modes of instruction in undergraduate science-content courses that help pre-service teachers develop future inquiry-based science instructional skills.</td>
</tr>
<tr>
<td></td>
<td>Educational researchers – conduct research to understand the best mode of instruction for science-content courses.</td>
</tr>
<tr>
<td>Teachers use specific inquiry-based practices in the elementary science classroom elementary science.</td>
<td>Educational researchers – conduct research into how best to offer teachers’ opportunities to develop PCK.</td>
</tr>
</tbody>
</table>
Creswell and Plano-Clark (2011) discuss the validity of mixed research designs, noting that both quantitative and qualitative aspects of the study require analysis that focuses on three phases: (a) data collection, (b) data analysis, and (c) research interpretation. The authors also point to the complexity and specific nature of mixed methods research as data in these studies are “connected and merged” (p. 239) by various analyses techniques.

However, potential validity threats can occur when merging or connecting data, according to Creswell and Plano-Clark (2011). For example, data collection issues arise when different sample populations are selected or two types of data are collected to address the same topics. The authors suggested that quantitative and qualitative samples from the

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<table>
<thead>
<tr>
<th>Finding</th>
<th>Implications for Researchers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers hold specific beliefs about inquiry and developing self-efficacy in the elementary science classroom.</td>
<td>Educational researchers – conduct longitudinal research to help identify which specific experiences help practicing teachers continue to develop PCK for scientific inquiry, emphasizing evidence and explanation throughout the course of their careers.</td>
</tr>
<tr>
<td>Self-efficacy was found to be a significant predictor of increased questioning and thinking skills in elementary classroom science instruction.</td>
<td>Educational researchers – conduct research that provides further understanding of the manner in which high school experiences impact the development of teachers’ scientific beliefs and attitudes.</td>
</tr>
<tr>
<td>Teachers believe that there are specific barriers to inquiry practices in the classroom in the elementary science classroom</td>
<td>Educational researchers – conduct research into how much time, training, and resources are necessary to teach science more soundly and cost-effectively.</td>
</tr>
</tbody>
</table>

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**Limitations**

Creswell and Plano-Clark (2011) discuss the validity of mixed research designs, noting that both quantitative and qualitative aspects of the study require analysis that focuses on three phases: (a) data collection, (b) data analysis, and (c) research interpretation. The authors also point to the complexity and specific nature of mixed methods research as data in these studies are “connected and merged” (p. 239) by various analyses techniques.
same population “make data comparable” (Creswell & Plano-Clark, 2011, p. 240) and that the same inquiry topic be addressed in both the qualitative and quantitative data collection. In the current study, the same sample of teachers were administered the original survey, and the items that explored classroom teachers effectiveness as science teachers were presented in both open and closed items in the study to the same participants.

Data analyses issues with merging or connecting data include making “illogical comparisons of the two results of analysis” (Creswell & Plano-Clark, 2011, p. 240) and using “inappropriate statistics to analyze quantitized qualitative results” (Creswell & Plano-Clark, 2011, p. 240). In the current study, the themes that emerged from the open-ended items helped to triangulate the Science Teaching Efficacy Belief Instrument (STEBI-A) (Personal Science Teaching Efficacy Beliefs subscale only) and the Classroom Practices Survey (CPS) mean score results. In turn, the open-ended responses helped to uncover major themes that shed light on the STEBI-A and CPS results offering a deeper understanding of the ways in which classroom teachers view good science teaching and the types of challenges that classroom teachers’ face when teaching science. Two researchers discussed each code and came to consensus, a process which lessened the likelihood of making illogical comparisons.

And finally, the authors note that interpretation issues with merging and connecting data can occur when divergent findings are not resolved and one type of data are weighted more than the other (Creswell & Plano-Clark, 2011). In all cases, the authors suggest that the findings should be interpreted in light of the “social science lens” (Creswell & Plano-Clark, 2011, p. 241). Again, in the current study, the qualitative analysis of the open-ended items triangulated the quantitative results found through the regression data analyses from research
questions one and two. These data analyses were performed with the mean score results from the STEBI-A and the CPS.

The quantitative and qualitative data sets were interpreted to “answer the mixed methods research questions” (Creswell & Plano-Clark, 2011, p. 242). It is hoped that the information gleaned from this study will offer researchers a deeper understanding of the manner in which the factors of gender (internal) and grade level taught, years of experience, highest degree earned, number of elective undergraduate science courses, science degree-yes or no (external) affect the science self-efficacy of in-service kindergarten through fifth grade teachers classroom elementary school teachers.

Purposeful sampling occurs when the researcher intentionally selects or recruits participants who “have experienced the central phenomenon or the key concept being explored” (Creswell & Plano-Clark, 2011, p.173). Kindergarten through fifth grade teachers were chosen for this study as these elementary-school teachers were required to teach classroom science in addition to their other curriculum topics, and were not specifically trained to teach science only. Therefore their opinions as to why science teaching was challenging were thought to be more authentic.

A sample of convenience was compiled from school districts convenient to the researcher’s place of residence. Kindergarten through fifth grade teachers who taught classroom science in the sample schools from the targeted districts were invited to participate in the study. The researcher attempted to minimize external validity threats by targeting approximately 160 teachers in the study from different schools. In an effort to limit non-response bias, the researcher attended scheduled faculty meetings to administer the survey or the building administer in charge administered the survey to participants in all but one
district. Non-response rate was low: 143 of the 160 teachers completed surveys, which increases the representation within the target sample. However, as this was a sample of convenience, the survey information from this select group may not be generalized to all K-5 elementary school classroom teachers who teach science. Therefore, the study may not have generalizability to teachers who work in elementary schools outside of the suburban metropolitan communities selected for this study. In an attempt to ensure that the study had improved generalizability, the researcher recruited districts with a greater percentage of free and reduced lunch and diverse demographics.

Although it is assumed that respondents answered all survey questions honestly and to the best of their abilities, this may not, in fact, be the case. One noteworthy problem was that, on the CPS survey, teachers indicated extreme assuredness regarding the frequency of their using higher order questioning and thinking methods in their classrooms. In the quantitative analysis of research question two, participants scored fairly highly on the CPS ($M = 4.39$) on a 6-point Likert scale, indicating that most participants utilized questioning strategies at least daily. Gall, et al. (2007) noted that one of the ecological validity factors identified by Bracht and Glass (1968), known as the Hawthorne Effect, may occur when participants are aware of participating in a study, and therefore respond accordingly. Participants in the current study may have responded to items in the manner they believed was expected of them, rather than in a manner representative of the actual practices in their classrooms.

As noted, the data for this research study was collected through the use of a survey that contained closed- and open-ended items. Although the two instruments selected, the STEBI-A and the CPS, appeared to be most aligned with the purposes of the study, the items
were limited in what they might reveal. Therefore, the five open-ended questions addressed personal beliefs and attitudes of the participants regarding classroom science teaching. However, the open-ended questions elicited data that was limited by the qualitative threats of applicability and transferability.

Krefting (1991) addressed the topics of applicability and transferability by stating that “not all qualitative research can be assessed with the same strategies [as quantitative research]” (Krefting, 1991, p.173). Qualitative researchers such as Guba (1981) have suggested a model for determining the trustworthiness of qualitative data. Guba’s model is based on four aspects of this concept: (a) truth value, (b) applicability, (c) consistency, and (d) neutrality.

Lincoln and Guba (1985) described truth value as the extent to which researchers are confident that their findings reflect the experiences and beliefs of the participants. In the current study, by utilizing open-ended questions, teachers’ experiences and beliefs were included in the study and offered insight to their responses to the STEBI-A and the CPS items. The data were checked by two researchers who later arrived at a consensus regarding the participants shared responses and deemed them appropriate and representative on elementary classroom teachers who teach science. Applicability refers to the ability and the degree to which the findings may be generalized to other populations. As previously stated, the study may lack generalizability, as all participants taught in schools in suburban metropolitan communities. However, eight districts across two eastern states in the US were sampled in the study.

Consistency refers to whether a researcher who replicates the study would find the same results with different participants. As noted by Krefting (1991), qualitative research by
definition permits the researcher to “learn from the informants rather than control for them” (p. 175). Therefore, variability included looking at the “range of experience” (Krefting, 1991, p. 175), rather than what is typical. The data gathered from the current study’s participants included the opinions of a variety of faculty members who ranged in age from new teachers with fewer than two years of experience, to those who were planning on retirement at the end of the year.

Lastly, Lincoln and Guba’s (1985) final aspect of trustworthiness, neutrality, refers to participants’ opinions being solely their own, and not reflecting those of the researcher or another outside source. In the current study, this was of particular concern, as some participants did know the researcher in her role as a science enthusiast. The researcher attempted to limit this threat by relying on the same introductory material that was read at each administration of the survey when the researcher was administering the survey. This procedure limited the extraneous remarks that might have impacted the participants’ thoughts and actions.

**Summary**

The research questions addressed in this study focused on the manner in which self-efficacy translates into pedagogically sound teaching strategies that kindergarten through fifth grade elementary school classroom teachers of science offer students for increased opportunities to practice questioning and thinking skills. A thorough review was made of the construct self-efficacy as well as those constructs associated with science self-efficacy such as competence, motivation, teacher knowledge, beliefs and attitudes, and the nature of science. The researcher then explored the relationship and the manner in which the factors of gender, grade level taught, years of classroom teaching experience, highest degree earned,
number of elective undergraduate science courses, and whether or not participants had earned a science degree predicted the level of self-efficacy for this particular group of science classroom teachers who work with younger elementary school students. And finally, teachers’ science self-efficacy was explored as a possible predictor of teachers’ instructional methods of questioning and thinking.

This study employed a convergent parallel mixed method research design that combined quantitative and qualitative approaches deemed appropriate for a more complete understanding of teachers’ beliefs. Three or more science courses and grade level, more specifically, the code for fifth grade teachers, were significant predictors of science self-efficacy skills in elementary classroom science instruction. Self-efficacy was found to be a significant predictor of increased questioning and thinking. The qualitative findings reported that teachers believed that it was important to foster student interest in order to generate student questions and that specific curriculum and teacher-based strategies encourage challenging content and higher-order thinking encourage student-centered active learning resulting in student questioning. Teachers reported both ascribing to and using specific inquiry-based practices in the elementary science classroom even when faced with challenges that prevented them from reaching these goals. These teachers also expressed specific beliefs about developing self-efficacy in the elementary-school science classroom.

The study’s implications initially impact secondary school administrators. Secondary science courses and requirements for both male and female entry level college students might structure high school science offerings so that these future entry-level undergraduates have both the credentials and self-efficacy necessary to be successful in future college science courses. College administrators and education faculty might also develop specific science
content courses for elementary education majors that assist pre-service elementary teachers develop PCK for their future work.

The teachers in the sample reported that professional development is more helpful to elementary school classroom teachers who teach science when it is on-going, authentic, and inquiry-based. Therefore, another implication of the findings suggests that school districts endeavor to provide opportunities that enhance science assessment, structure curriculum, and mentor colleagues to support teachers developing science self-efficacy. In this age of financial constraints, school district personnel may wish to investigate funding sources for materials and encourage experiences that encourage active science learning by linking services and opportunities for collaboration with community science organizations and industry that promotes STEM exploration.

Future research is needed into the identification of specific combinations of secondary and undergraduate science courses most beneficial to elementary school education teachers. Future longitudinal research might also help in identifying the experiences, challenges, and solutions practicing elementary school classroom teachers of science require when developing PCK for inquiry-based science teaching.

Conclusion

Clearly, for elementary school science reform to move forward, close partnerships must be forged between and among the stakeholders: administrators, teachers, and students. However, educators agree that the teacher/student relationship is a uniquely balanced combination of instructional methods and student understanding. Teacher beliefs are at the center of this combination. The elementary school classroom can be the reflection of advanced science understandings by offering students opportunities to question, to explore
and to discover how their world exists. Science content knowledge and pedagogical knowledge, when united, empowers teachers to teach elementary school science using effective inquiry-based instructional methods. Teachers’ self-efficacy toward the teaching of science, however, is the bridge that connects classroom teachers’ use of innovative and responsive instruction with student engagement and creative thinking resulting in true science knowledge advancement. As Albert Einstein once said, “To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science” (Einstein & Infeld, 1938, p. 92).
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Appendix A: The Classroom Science Instruction Survey (CSIS)
The Classroom Science Instructional Survey

This study will examine kindergarten through fifth grade elementary school teachers’ self-efficacy beliefs regarding classroom science teaching and then relate these findings to the regular classroom practices that elementary school classroom teachers find useful when teaching science. The survey contains three sections: Teacher Information; Teacher Beliefs; and Classroom Practices. You can help us learn more about these practices by taking a few minutes to complete this questionnaire. Please be assured that your answers are confidential.

I. TEACHER INFORMATION

1. Gender Please check the box that best describes you.

[ ] Male

[ ] Female

2. Grade level you currently teach (select one):

[ ] K [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

Multi-level_______ Grades:_________

3. Years of experience teaching classroom science______________

4. Highest Degree Earned

[ ] BA/BS

[ ] MA/MS

[ ] Ph.D./Ed.D or equivalent
5. How many \textit{elective} undergraduate science courses have you taken?

<table>
<thead>
<tr>
<th></th>
<th>none</th>
<th>1–2</th>
<th>3–4</th>
<th>5 or more</th>
</tr>
</thead>
</table>

6. Do you have a science degree?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

IIa. TEACHER BELIEFS

Please answer the following questions fully. You may use the back of these sheets if you need more room.

7. How do good teachers teach elementary school science well?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
8. Are there any experiences outside the classroom that you believe have increased your effectiveness as a classroom science teacher?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

9. What do you think you do well when you are teaching science?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

10. What are some of the challenges you face when teaching science?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
11. How do you encourage students’ questioning and thinking skills in your classroom?


IIb. TEACHER BELIEFS (Continued)

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

12. I am continually finding better ways to teach science.     SA  A  UN  D  SD
13. Even when I try very hard, I do not teach science as well as I do most subjects.     SA  A  UN  D  SD
14. I know the steps necessary to teach science concepts effectively.     SA  A  UN  D  SD
15. I am not very effective in monitoring science experiments.     SA  A  UN  D  SD
16. I generally teach science ineffectively.     SA  A  UN  D  SD
<table>
<thead>
<tr>
<th>#</th>
<th>Statement</th>
<th>SA</th>
<th>A</th>
<th>UN</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>I understand science concepts well enough to be effective in teaching elementary school science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>I find it difficult to explain to students why science experiments work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>I am typically able to answer students' science questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>I wonder if I have the necessary skills to teach science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Given a choice, I would not invite the principal to evaluate my science teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>When teaching science, I usually welcome student questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>I do not know what to do to turn students on to science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
III. Classroom Practices

This section is designed to provide information about the instructional strategies and approaches you use in your elementary school classroom to teach science. It is very important that the answers you provide reflect actual practices. Please be assured that your individual responses will be confidential. Please read the directions below and then proceed as directed. Please use the following response scale based on the academic year to indicate what actually occurs in your classroom. Circle the most appropriate response.

Response Scale

0 - Never
1 - Once a month, or less frequently
2 - A few times a month
3 - A few times a week
4 - Daily
5 - More than once a day

25. Teach thinking skills in the regular curriculum

26. Provide questions that encourage reasoning and logical thinking

27. Ask open-ended questions

28. Encourage students to ask higher-level questions

29. Encourage student participation in discussions
Appendix B: Teacher Demographic Information Response Items from the CSIS
I. TEACHER INFORMATION

1. **Gender** Please check the box that best describes you.

   [ ] Male
   [ ] Female

2. Grade level you currently teach (select one):

   [ ] K  [ ] 1  [ ] 2  [ ] 3  [ ] 4  [ ] 5

   Multi-level_______ Graded:_________

3. Years of experience teaching classroom science___________

4. Highest Degree Earned

   [ ] BA/BS
   [ ] MA/MS
   [ ] Ph.D./Ed.D or equivalent

5. **How many elective** undergraduate science courses have you taken?

   [ ] none  [ ] 1 – 2  [ ] 3 - 4  [ ] 5 or more

6. **Do you have a science degree?**

   [ ] Yes  [ ] No
Appendix C: Teacher Beliefs: Open Response Items from the CSIS
IIa. TEACHER BELIEFS

Please answer the following questions fully. You may use the back of these sheets if you need more room.

7. How do good teachers teach elementary school science well?

______________________________________________________________

8. Are there any experiences outside the classroom that you believe have increased your effectiveness as a classroom science teacher?

______________________________________________________________

9. What do you think you do well when you are teaching science?

______________________________________________________________

10. What are some of the challenges you face when teaching science?

______________________________________________________________

11. How do you encourage students’ questioning and thinking skills in your classroom?

______________________________________________________________
Appendix D: Science Teaching Efficacy Belief Instrument (STEBI – A)

Personal Science Teaching Efficacy Beliefs Subscale

Science Teaching Outcome Expectancy Subscale
<table>
<thead>
<tr>
<th></th>
<th>Statement</th>
<th>SA</th>
<th>A</th>
<th>UN</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>When a student does better than usual in science, it is often because the teacher exerted a little extra effort.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>I am continually finding better ways to teach science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Even when I try very hard, I do not teach science as well as I do most subjects.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4</td>
<td>When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>I know the steps necessary to teach science concepts effectively.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>I am not very effective in monitoring science experiments.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>If students are underachieving in science, it is most likely due to ineffective science teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>I generally teach science ineffectively.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>The inadequacy of a student's science background can be overcome by good teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>The low science achievement of some students cannot generally be blamed on their teachers.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>11</td>
<td>When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>12</td>
<td>I understand science concepts well enough to be effective in teaching elementary school science.</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
13. Increased effort in science teaching produces little change in some students' science achievement.

14. The teacher is generally responsible for the achievement of students in science.

15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.

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.

17. I find it difficult to explain to students why science experiments work.

18. I am typically able to answer students' science questions.

19. I wonder if I have the necessary skills to teach science.

20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.

21. Given a choice, I would not invite the principal to evaluate my science teaching.

22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.

23. When teaching science, I usually welcome student questions.

24. I do not know what to do to turn students on to science.

25. Even teachers with good science teaching abilities cannot help some kids to learn science.
Appendix E: STEBI-A Survey Items for 
Personal Science Teaching Efficacy Beliefs Subscale (Only)
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.

<table>
<thead>
<tr>
<th></th>
<th>Statement</th>
<th>SA</th>
<th>A</th>
<th>UN</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I am continually finding better ways to teach science.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>Even when I try very hard, I do not teach science as well as I do most subjects.</td>
<td></td>
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<tr>
<td>3</td>
<td>I know the steps necessary to teach science concepts effectively.</td>
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</tr>
<tr>
<td>4</td>
<td>I am not very effective in monitoring science experiments.</td>
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<td></td>
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<tr>
<td>5</td>
<td>I generally teach science ineffectively.</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
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<td>7</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>10</td>
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<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>12</td>
<td>When teaching science, I usually welcome student questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>I do not know what to do to turn students on to science.</td>
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</tbody>
</table>

Appendix F: The National Research Center on the Gifted and Talented (NRC/GT) Classroom Practices Survey (CPS)
Classroom Practices NRC/GT - Teacher Survey

The National Research Center on the Gifted and Talented
University of Connecticut University of Georgia
University of Virginia Yale University

This study focuses on the nature of regular classroom practices used in schools across the United States. You can help us learn more about these practices by taking a few minutes to complete this questionnaire. Please be assured that your answers will be kept strictly confidential and that all reporting will be done at the group level.

I. Teacher Information

Please check the box that describes you.

1. Gender Male Female

2. Ethnicity

Hispanic-American African-American Native-American
Caucasian-American Asian-American/Pacific Islander Other (____________)

3. Years of teaching experience ____________

4. Highest Degree Earned

BA/BS MA/MS (Sixth year/Ed. Spec.)
Ph.D./Ed.D. Professional Diploma Other (____________)

5. Training in teaching of gifted/talented

(Check all that apply)

None District inservice Workshop Outside District
Course(s) at college/university Educational degree in area

6. Grade level now teaching ____________
II. School and District Information

Please answer the following questions about your school and district.

1. Using the scale below, what percent of students in your school belong to each of the following ethnic groups?

   0 = 0%, 1 = Up to 10%, 2 = 11% to 25%, 3 = 26% to 50%, 4 = 51% or more, 5 = Don’t Know

   ____ African-American
   ____ Asian-American/Pacific Islander
   ____ Hispanic-American
   ____ Native-American
   ____ Caucasian-American
   ____ Other

2. Has a formal definition of giftedness been adopted by your district?

   Yes     No     Don’t Know

3. What is the lowest grade level for which there is a formal gifted program in your district?

   __________________

4. Which of the following measures and/or checklists does your district use to formally identify gifted students? (Check all that apply)

   IQ Tests (Group or Individual)   Teacher Nomination Creativity Tests
   Achievement Tests   Parent Nomination     Don’t Know
   Grades   Student Self-Nomination   Other, Specify: ______________________________
   Teacher Rating Scales   Student Interview ____________________
   Student Products/Portfolios   Peer Nomination ________________
5. Does your district have a policy regarding the acceleration of the regular curriculum for high ability students?

Yes    No    Don’t Know

If yes, which of the following applies?

Classroom teachers are encouraged to accelerate students into the next level or the next academic grade.

Classroom teachers are encouraged to provide higher level or enriched content material in their classrooms, but are not permitted to accelerate students into the next level or academic grade.

Classroom teachers are not allowed to provide advanced level curriculum for higher ability students and are not permitted to accelerate students into the next level or academic grade.

Other (Specify _____________________________________________)

6. Does your school district employ a coordinator of programs for the gifted?

Yes   No   Don’t Know

7. Is there a full-time teacher of the gifted in your school building?

Yes   No   Don’t Know

8. Is there a part-time teacher of the gifted in your school building?

Yes   No   Don’t Know

9. Do students in your school building participate in a gifted program in which they are transported to a different school or site?

Yes   No   Don’t Know

10. Do students in your school go to a resource room (pull-out program) for instruction provided by a teacher of the gifted?
III. Classroom Issues

Please answer the questions below regarding issues in your classroom.

1. Which of the following best describes the type of class you teach?
   
   Intact or self-contained class (i.e., the same students all day)
   
   Departmentalized arrangement (i.e., teach one or more subjects to different classes)

2. If you teach an intact class, please skip to question 3 and answer the remaining questions in this section for that class. If you teach in a departmentalized arrangement, please select one (1) class and answer the remaining questions in this section based on that class. Please indicate which class you have selected.

   Science    Social Studies    Language Arts
   Math    Reading    Art
   
   Other (Specify ____________________________)

3. What is the enrollment of your class by gender? (Give number) _____ Boys _____ Girls

4. Indicate the number of limited English proficient students in your classroom.___________

5. Indicate the number of students in your classroom for each of the following groups.

   ____ Visually Impaired
   ____ Hearing Impaired
   ____ Physically Handicapped (Muscle Impairment)
   ____ Other Health Impairment (Specify ____________________________)

6. What is the number of students in your class for each of the following ethnic groups? (Give number)
___ African-American
___ Asian-American/Pacific Islander
___ Hispanic-American
___ Native-American
___ Caucasian-American
___ Other

7. What is the number of formally identified gifted students in your classroom? __________________________.

8. Which of the following measures and/or checklists do you use (or if you don’t have a gifted program, would you use) to identify gifted students in your classroom?

(Check all that apply)

IQ Tests (Group or Individual)  Teacher Nomination  Creativity Tests
Achievement Tests  Parent Nomination  Don't Know
Grades  Student Self-Nomination  Other, Specify:__________________________
Teacher Rating Scales  Student Interview ___________
Student Products/Portfolios  Peer Nomination _______________

9. Are there students in your class you believe are gifted but have not been formally identified as such by your district?

Yes  No  Don't know

10. Indicate the number of limited English proficient students in your classroom who are formally identified as gifted and also those who may be gifted but are not formally identified as such.

Formally Identified  - May be Gifted But Not As Gifted __________
Formally Identified

11. Indicate the number of students in your classroom formally identified as gifted and also those who may be gifted but are not formally identified as such for each of the following groups:
Formally Identified May be Gifted But Not
As Gifted Formally Identified
Visually impaired ________ ________
Hearing Impaired ________ ________
Physically Handicapped ________ ________
Other Health Impairment (specify) ________ ________

12. How many boys and girls in your classroom have been formally identified as gifted and how many may be gifted but have not been formally identified as such for each of the ethnic groups listed below?
Formally Identified May be Gifted But Not
As Gifted Formally Identified
Boys Girls Boys Girls
African-American ________ ________ ________ ________
Asian-American/Pacific Islander ________ ________ ________ ________
Hispanic-America ________ ________ ________ ________
Native-American ________ ________ ________ ________
Caucasian-American ________ ________ ________ ________
Other ________ ________ ________ ________
IV. Classroom Practices

This section is designed to provide information about the instructional strategies and approaches you use in your classroom. It is very important that the answers you provide reflect actual practices. Please be assured that your individual responses will be held in the strictest confidence.

Above you told us whether you teach an intact class or specific subject(s) (i.e., departmentalized arrangement). If you teach an intact class, please respond to the following items for that class. If you teach in a departmentalized arrangement, please respond to the following items using the same class you selected earlier as your point of reference. PLEASE DO NOT CHANGE CLASSES.

Please read the directions below, check one of the boxes, and then proceed as directed.

1) If you have students in your class formally identified as gifted by your district, check box one (1) and respond to items 1-39 for Average AND Gifted students.

2) If you do not have students in your class formally identified as gifted by your district but have students you believe are gifted, check box two (2) and respond to items 1-39 for Average AND Gifted students.

3) If you have neither students formally identified by the district as gifted nor students you believe are gifted, check box three (3) and respond to items 1-39 for Average students only.

Please use the following response scale based on the academic year to indicate what actually occurs in your classroom. Circle the most appropriate response.

Response Scale

0 - Never

1 - Once a month, or less frequently
2 - A few times a month
3 - A few times a week
4 - Daily
5 - More than once a day

<table>
<thead>
<tr>
<th>Average</th>
<th>Gifted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>Students</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>2. Use enrichment worksheets</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>3. Assign reading of more advanced level work</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>4. Use self-directed instructional kits such as S.R.A.</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>5. Assign reports</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>6. Assign projects or other work requiring extended time for students to complete</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>7. Assign book reports</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>8. Use activities such as puzzles or word searches</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>9. Give creative or expository writing assignments on topics selected by the teacher</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>10. Give creative or expository writing assignments on topics selected by the students</td>
</tr>
</tbody>
</table>

Response Scale

0 - Never
1 - Once a month or less frequently
2 - A few times a month

3 - A few times a week

4 - Daily

5 - More than once a day

<table>
<thead>
<tr>
<th>Average Students</th>
<th>Gifted Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
</tbody>
</table>

11. Make time available for students to pursue self-selected interests

12. Use pretests to determine if students have mastered the material covered in a particular unit or content area

13. Eliminate curricular material that students have mastered

14. Repeat instruction on the coverage of more difficult concepts for some students

15. Substitute different assignments for students who have mastered regular classroom work

16. Modify the instructional format for students who learn better using an alternative approach

17. Encourage students to move around the classroom to work in various locations

18. Allow students to leave the classroom to work in another location, such as the school library or media center

19. Assign different homework based on student ability

20. Use learning centers to reinforce basic skills
| 0 1 2 3 4 5 | 21. Use enrichment centers | 0 1 2 3 4 5 |
| 0 1 2 3 4 5 | 22. Teach thinking skills in the regular curriculum | 0 1 2 3 4 5 |
| 0 1 2 3 4 5 | 23. Teach a unit on a thinking skills, such as critical thinking or creative problem solving | 0 1 2 3 4 5 |
| 0 1 2 3 4 5 | 24. Participate in a competitive program focusing on thinking skills/problem solving, such as Future Problem Solving, Odyssey of Mind, etc. | 0 1 2 3 4 5 |
| 0 1 2 3 4 5 | 25. Use contracts or management plans to help students organize their independent study projects | 0 1 2 3 4 5 |
| 0 1 2 3 4 5 | 26. Provide time within the school day for students to work on their independent study projects | 0 1 2 3 4 5 |
| 0 1 2 3 4 5 | 27. Allow students within your classroom to work from a higher grade level textbook | 0 1 2 3 4 5 |
| 0 1 2 3 4 5 | 28. Provide a different curricular experience by using a more advanced curriculum unit on a teacher-selected topic | 0 1 2 3 4 5 |

**Response Scale**

0 - Never

1 - Once a month or less frequently

2 - A few times a month

3 - A few times a week

4 - Daily

5 - More than once a day
<table>
<thead>
<tr>
<th>Average Students</th>
<th>Gifted Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>29. Group students by ability across classrooms at the same grade level</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>30. Send students to a higher grade level for specific subject area instruction</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>31. Establish interest groups which enable students to pursue individual or small group interests</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>32. Consider students' opinion in allocating time for various subjects within your classroom</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>33. Provide opportunities for students to use programmed or self-instructional materials at their own pace</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>34. Give assignments that encourage students to organize their own work schedule to complete a long range project</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>35. Provide questions that encourage reasoning and logical thinking</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>36. Ask open-ended questions</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>37. Encourage students to ask higher-level questions</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>38. Encourage student participation in discussions</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>39. Use computers</td>
<td>0 1 2 3 4 5</td>
</tr>
</tbody>
</table>
COMMENTS

Please provide any comments you believe will help us in understanding classroom practices within your school.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
Appendix G: NRC/GT Classroom Practices Survey
Questioning and Thinking Subscale (only)
Classroom Practices

This section is designed to provide information about the instructional strategies and approaches you use in your elementary school classroom to teach science. It is very important that the answers you provide reflect actual practices. Please be assured that your individual responses will be held in strictest confidence.

Please read the directions below and then proceed as directed. Please use the following response scale based on the academic year to indicate what actually occurs in your classroom. Circle the most appropriate response.

Response Scale

0 - Never
1 - Once a month, or less frequently
2 - A few times a month
3 - A few times a week
4 - Daily
5 - More than once a day

1. Teach thinking skills in the regular curriculum

2. Provide questions that encourage reasoning and logical thinking

3. Ask open-ended questions

4. Encourage students to ask higher-level questions

5. Encourage student participation in discussions
Appendix H: Permission to Use and Publish Instruments
Subj: Re: STEBI
Date: 2/18/2010 11:05:35 P.M. Eastern Standard Time
From: enochsl@onid.orst.edu
To: MrsMumphie@aol.com
You have permission to use it. Please let me know how it goes. Good luck.

On Feb 18, 2010, at 7:49 AM, MrsMumphie@aol.com wrote:

> Hello Dr. Enochs:
> >
> > I telephoned earlier to speak with you regarding the use of your
> > STEBI for research purposes. I am a third year doctoral student at
> > Western Connecticut State University, and I have an interest in
> > Inquiry -Based Science Teaching.
> >
> > My research plans are to look at the self-efficacy of K -5th grade
> > elementary school teachers and examine the factors that have shaped
> > their science instruction.
> >
> > I am interested in administering the STEBI on two different occasions.
> > First, I am doing a pilot study for a program evaluation course. I
> > would like to administer the STEBI to my home district’s teachers at
> > one of our elementary schools.
> >
> > Second, I am considering the STEBI for my dissertation work.
> >
> > I would appreciate purchasing info as that has been difficult to
> > acquire...
> >
> > Any assistance you could offer me is much appreciated.
> >
> > Sincerely,
> > Deborah Mumford
> > H. Telephone: 914-276-3259
> > M. Telephone: 914-720-7861
> >
> Larry G Enochs
> Professor
> Science and Mathematics Education
> 231 Weniger Hall
> Oregon State University
> Corvallis, OR 97331
> 541-737-1305
> http://sm.ed.science.oregonstate.edu/node/42

"Students should continue to learn and use their learning in more
effective problem solving for the rest of their lives. When one takes
life-long learning and thinking as the major goal of education,
knowledge becomes a means rather than an end, and other formerly
implicit goals become more explicit." (McKeachie et al, 1988, p.1.)
November 30, 2010

Dr. Nancy N. Heilbronner
Assistant Professor, Instructional Leadership
Western Connecticut State University
181 White Street
Danbury, CT 06810

Dear Nancy:

I am pleased that one of your graduate students is interested in using the Classroom Practices Survey developed by The National Research Center on the Gifted and Talented under a grant from the United States Department of Education. I understand the Deb Mumford’s dissertation will examine the self-efficacy of practicing science teachers. The Classroom Practices Survey is available on our website (http://www.gifted.uconn.edu/nrcgt/reports/rm93102/rm93102.pdf).

The instrument is not copyrighted. You have permission to use the instrument. Please include the statement below:

Research for this report was supported under the Javits Act Program (Grant No. R206R00001) as administered by the Office of Educational Research and Improvement, U.S. Department of Education. Grantees undertaking such projects are encouraged to express freely their professional judgement. This report, therefore, does not necessarily represent positions or policies of the Government, and no official endorsement should be inferred.

This document has been reproduced with the permission of The National Research Center on the Gifted and Talented.

When the dissertation research is completed, I would appreciate receiving a summary of the findings for our records.

Sincerely,
E. Jean Gubbins, Ph.D.
Associate Director, The National Research Center on the Gifted and Talented

**An Equal Opportunity Employer**

2131 Hillside Road Unit 3007
Storrs, Connecticut 06269-3007

Telephone: (860) 486-4676
Facsimile: (860) 486-2900
web: www.gifted.uconn.edu
You may include it in your appendix.

On Apr 2, 2012, at 7:09 PM, MrsMurphys@act.com wrote:

Hello Dr. Enochs:

I know that it has been awhile, but I had contacted you and Dr. Rijgs to ask permission to use the STEBI-A back on February 18, 2010 for my dissertation research on elementary school classroom teachers' self-efficacy in science teaching. You had kindly granted me that permission, and I have included your email in my appendices.

You will be happy to know that I did complete the dissertation and successfully defended on March 31st, this past Saturday. I appreciated that permission to use the instrument, and I did find significance regarding certain factors. I would be happy to send along an electronic copy once I finish preparing the dissertation for publishing.

However, I wanted to ask you to specifically grant me permission to include a copy of the survey in my appendices (credited, of course) as I had only asked permission to use it, and not print it in the dissertation.

If you are in agreement with this, might you reply to me at the above email address???

Thank you so much...I appreciate your help...Looking forward to hearing from you, Dr. Enochs.

Sincerely,
Debbie Mumford
Debbie Mumford

It sounds like you have made great progress with your research. Of course, you may use the survey as part of your appendices. It is not copyrighted. Just include the source and a note about your modifications.

E. Jean Gubbins

E. Jean Gubbins, Ph.D.
Associate Professor
Director
The National Research Center on the Gifted and Talented
University of Connecticut
2131 Hillside Road Unit 3007
Storrs, CT 06269-3007
Phone: 860-486-4041
Fax: 860-486-2900

From: "MrsMumphie@aol.com"<mailto:MrsMumphie@aol.com>" <MrsMumphie@aol.com><mailto:MrsMumphie@aol.com>
Date: Mon, 2 Apr 2012 21:57:29 -0400
To: E. Jean Gubbins <jean.gubbins@uconn.edu><mailto:jean.gubbins@uconn.edu>
Subject: Permission to include Instrument in Mumford Dissertation

Dear Dr. Gubbins:

My name is Deborah Mumford (soon to be EdD), and a doctoral candidate at Dr. Nancy Heilbronner at WCSU.

You were kind enough to grant me permission to use the Classroom Practices Survey in my dissertation research on self-efficacy of practicing elementary...
Appendix I: Introductory Script for Researcher-Administered Survey
Good Afternoon. My name is [Debbie Mumford] as your [principal, building representative] has mentioned. I thank [name of administrator, superintendent] for permitting me to visit you this afternoon, and I thank you in advance for sharing part of your meeting time with me. I am here to ask you to participate in a research study. My study is focused on understanding how elementary teachers feel about teaching science in their classroom. If you are a kindergarten through fifth grade teacher here at [name of school], I am asking you to complete a survey of about 29 questions that should not take more than 20 minutes or so to complete. At the conclusion of the survey, I have a fun surprise raffle that I would like to ask all of you participating in the survey today to take part in. This is just a very small way I would like to say thank you for taking the time to help me today.

Please know that I am very appreciative of your time and your thoughts this afternoon. I am asking you to carefully read the consent form, and to please sign the form as I have indicated. I am also asking you to write your first name on the little piece of paper and turn both the paper and the survey into me when you are finished. Your signature is very important. It gives me permission to share your individual thoughts in my study. Please answer the questions as honestly as possible. No one from your school or your district will be made aware of your individual or group responses as all the information for the study will be combined.
I realize that some of you may know me from my prior visit to your school in my work as a naturalist educator. For some of you, it may surprise you to know that I have been teaching kindergarten at Seely Place Kindergarten for the past 6 years. I have also been working on this doctorate for some time. Again, I appreciate your time this afternoon. If you have any questions about the study, please feel free to call me or email me. All my contact information can be found on the contact sheet. Please know that your thoughts and thoughts from other teachers in a few other districts are important to me and my research into how teachers feel about elementary classroom science instruction.
Appendix J: Informed Consent
Principal Investigator: Deborah Mumford
Faculty Advisor: Nancy N. Heilbronner, Ph.D.

Title of Study: An Examination of the Factors Related to Elementary school Classroom Teachers' Self-Efficacy and the Impact of Self-Efficacy Beliefs on Teaching Outcomes in Science

You are invited to participate in a study, An Examination of the Factors Related to Elementary school Classroom Teachers' Self-efficacy and the Impact of Self-Efficacy Beliefs on Teaching Outcomes in Science, because you are an elementary school school teacher in grades K-5. The purpose of the study is to examine the factors that influence elementary school classroom teachers' self-efficacy and teaching outcomes in science. Your participation in this study is completely voluntary and will require completion of a teachers’ survey that will take approximately 20 minutes of your time. The researcher will collect your form once it is completed and your individual information will not be shared. Your participation will be confidential. You will not be paid for being in this study, however there will be a raffle for participants in which one gift card to Borders Books (value $15 each) will be distributed per school.

This survey does not involve any risk to you. However, the benefits of your participation may impact education by helping to create a deeper understanding and examination of self-efficacy and its relationship to more effective science teaching.

You do not have to be in this study if you do not want to be. I will be happy to answer any questions you have about this study. If you have further questions about this project or if you have a research-related problem, you may contact Deborah Mumford at (914) 472-8040 ext. 3318. This study has received approval from the WCSU Institutional Review Board (IRB), and if you have any questions about your rights as a research participant, you may contact them at (203) 837-8563. The IRB is a group of individuals who review research studies to protect the rights and welfare of research participants.

If you are 18 years of age or older and wish to participate in the study, please sign the form below and then continue to the next page.
Sincerely,
Deborah Mumford

Permission Agreement

Participant Signature ______________________________ Date ______________
Appendix K: Cover Letter and Consent Form (Superintendent)
Superintendent of Schools
[Title]
[Company Name]
[Street Address]
[City, ST ZIP Code]

Dear _______:  

I am currently enrolled in the doctoral program for Instructional Leadership at Western Connecticut State University. This program requires that I design and implement a dissertation research study. The purpose of the study, AN EXAMINATION OF THE FACTORS RELATED TO ELEMENTARY SCHOOL CLASSROOM TEACHERS' SELF-EFFICACY AND THE IMPACT OF SELF-EFFICACY BELIEFS ON TEACHING OUTCOMES IN SCIENCE, is to examine the factors that may be related elementary school classroom teachers' self-efficacy and also to examine whether self-efficacy in science teaching is related to teaching outcomes.

As part of this research, teachers in K-5th grade who teach science will be asked to complete a survey, the Classroom Science Instructional Survey, that will ask teachers questions regarding their beliefs about how best to teach science and also how they feel about their own science teaching. Survey completion will require approximately 20 minutes and may be presented and completed during a scheduled faculty meeting at a mutually agreed upon time with building principals.

This research study has been reviewed and approved by Western Connecticut State University’s Institutional Review Board. Results of this study will enable educators to further the conversation on how to best encourage classroom teachers to teach science more often and with more innovative methods. All responses will be held strictly confidential.

In preparation for my study, I have contacted building principals throughout Westchester, to determine interest in participation. ___________________________ at ___________________________ has consented to participate in my research. I wish to thank the ___________________________ school district for participating in this study and for contributing to the body of research that supports the goal of motivating teachers to achieve the goal of more effective science teaching.
Thank you for your cooperation and contribution to this research study. Please sign and return this form in the enclosed pre-addressed envelope, or indicate your consent to participate in the follow-up e-mail that you will be receiving shortly.

Sincerely,

Deborah Mumford  
Candidate for ABD in Instructional Leadership  
teacher.beliefsdm@gmail.com

***************************************************************************
***  

Permission Agreement

I agree that the study describe above can be conducted in _________________(name of district)  

________________________________________________________________________

Please Print Name of Superintendent

________________________________________________________________________

Signature of Superintendent  
Date
Appendix L: Cover Letter and Consent Form (Principal)
Dear [Principal],

This cover letter and the accompanying consent form are intended to encourage participation in my doctoral research study in instructional leadership at Western Connecticut State University. The purpose of the study is to examine the factors that influence elementary school classroom teachers' self-efficacy and teaching outcomes in science. I have contacted, and received permission for participation from your school district’s Superintendent (see enclosed sample of letter).

As part of this research, teachers in K-5th grade who teach science will be asked to complete a survey, the Classroom Science Instructional Survey, which will ask questions regarding teachers’ beliefs about how best to teach science and also how they feel about their own science teaching. Survey completion will require approximately 20 minutes, and I would like to request that the survey instructions and survey be administered by myself at a scheduled faculty meeting during the months of March or April, at a mutually accepted date. **Participation in this study is completely voluntary. The questionnaires are coded to ensure that all responses will be held strictly confidential. Copies of the results of the complete study will be made available to you. Please indicate your interest in receiving the completed data summary on the enclosed consent form. Individual teacher responses will not be made available.**

If you have any questions, or would like further information about the study, please contact me via email me at teacher.beliefsdm@gmail.com

Thank you for your cooperation and contribution to this research study. Please sign and return this form in the enclosed pre-addressed envelope, or indicate your consent to participate in the follow-up e-mail that you will be receiving shortly.

Sincerely,

Deborah Mumford
Permission Agreement

☐ I would like to receive results of this research study.

Name of School___________________________________

District__________________________________________

Name of Principal__________________________________

Signature of Principal_______________________________ Date _______________
Appendix M: Audit Trail for Research
# Audit Trail

## Classroom Teachers’ Science Self-efficacy and Instructional Method Research

### January 2011 – March 2012

<table>
<thead>
<tr>
<th>Date</th>
<th>Task</th>
<th>Stakeholders</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/31/11</td>
<td>Request district administrators’ interest in study</td>
<td>researcher/district administrators</td>
<td>This was done via study’s <a href="mailto:email-teacher.beliefsdm@gmail.com">email-teacher.beliefsdm@gmail.com</a></td>
</tr>
<tr>
<td>2/14/11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/11/11</td>
<td>Request permission from Superintendents’ of school districts for principal and teacher participation.</td>
<td>researcher/superintendents/district administrators of curriculum and instruction</td>
<td></td>
</tr>
<tr>
<td>2/11/11</td>
<td>Principals review process and plan</td>
<td>researcher/principals</td>
<td>Letter mailed/e-mailed to principals.</td>
</tr>
<tr>
<td>3/1/11</td>
<td></td>
<td>Researcher/principals</td>
<td></td>
</tr>
<tr>
<td>2/28/11</td>
<td>Request formal participation from principals. (this includes both a letter of explanation and consent form)</td>
<td>researcher/principals</td>
<td>A signature and or e-mail consent is required of each principal.</td>
</tr>
<tr>
<td>4/25/11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/7/11</td>
<td>Principals provided researcher with access to faculty members:</td>
<td>researcher/principals</td>
<td>Researcher suggests a general staff meeting, or faculty gathering</td>
</tr>
<tr>
<td>5/3/11</td>
<td>District A – 4/5/11; *District B-3/9/11 and *3/8/11</td>
<td>researcher/faculty members</td>
<td></td>
</tr>
<tr>
<td></td>
<td>District C – 3/7/11; *District D – 3/7/11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*District E – 4/3/11-4/14/11; District F – 4/26/11 and 5/3/11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*see below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/28/11</td>
<td>Each survey is coded with abbreviation and number to reference participating school.</td>
<td>researcher</td>
<td>Identification of surveys from each school participating in the study</td>
</tr>
<tr>
<td>5/1/11</td>
<td></td>
<td></td>
<td>Ex. AIS-001</td>
</tr>
<tr>
<td>2/28/11</td>
<td>Purchased 10 Barnes and Noble $15 gift cards for incentive raffle following survey completions at participating schools</td>
<td>researcher</td>
<td>All participating teachers at each school’s faculty gathering (where permitted) will be</td>
</tr>
<tr>
<td>Date</td>
<td>Task</td>
<td>Stakeholders</td>
<td>Notation</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>--------------</td>
<td>----------</td>
</tr>
<tr>
<td>3/8/11</td>
<td>Surveys administered without researcher:</td>
<td>District superintendent for curriculum and instruction</td>
<td>These districts/schools chose to participate, but requested that researcher not self-administer the survey. Following the administration of the survey, the researcher visited the school and retrieved the completed surveys. The teachers at these schools did not participate in the reward incentive.</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>and Principal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surveys administered by researcher:</td>
<td>Principals/</td>
<td></td>
</tr>
<tr>
<td>4/14/11</td>
<td>District B-Principal of Sampled School 2 administered survey herself;</td>
<td>to faculty members at the request of district superintendent and principal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>District D - District superintendent for curriculum and instruction downloaded/administered survey for sampled school;</td>
<td>District</td>
<td></td>
</tr>
<tr>
<td></td>
<td>District E- Teacher distributed surveys to interested K-5 faculty members at the request of district superintendent and principal</td>
<td>superintendent</td>
<td></td>
</tr>
<tr>
<td>3/7/11</td>
<td>Surveys administered by researcher:</td>
<td>District</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>A; District B, sampled School 1; District C; District F</td>
<td></td>
</tr>
<tr>
<td>5/3/11</td>
<td>F</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At faculty gathering, verbal instructions and information provided to teachers outlining the specific steps and expectations for the completion of surveys. Request teacher participation in the study (this includes a letter of explanation that concludes with a consent form) at the faculty meeting/gathering; administer the survey, and collect completed surveys</td>
<td>researchers/K-5 classroom faculty members</td>
<td>Each survey has a consent page to be signed by participating K-5 classroom teacher who teaches science. Those faculty members wishing to participate will be asked to return signed survey at the gathering.</td>
</tr>
<tr>
<td>3/9/11</td>
<td>Raffle Participation at District A; District B, sampled School 1; District F, sampled School 1 and 2 only</td>
<td>researcher/faculty members</td>
<td>All participating teachers at these school’s faculty gatherings were permitted to participate in the Barnes and Noble $15 raffle. Process: First names only were placed on separate pieces of paper (equal size and color paper slips) distributed with the surveys and handed in with completed surveys. The principal drew two names and winners were</td>
</tr>
<tr>
<td>5/3/11</td>
<td></td>
<td></td>
<td>entered in a Barnes and Noble $15 raffle. Two cards will be made available at each drawing.</td>
</tr>
<tr>
<td>Date</td>
<td>Task</td>
<td>Stakeholders</td>
<td>Notation</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3/8/11</td>
<td>Quantitative data entry in Microsoft 2007 EXCEL document.</td>
<td>researcher</td>
<td>announced at the faculty meetings at the conclusion of the survey</td>
</tr>
<tr>
<td></td>
<td>- Qualitative data entered onto a Microsoft Word 2010</td>
<td></td>
<td>As each school completed the survey, the data were entered</td>
</tr>
<tr>
<td>5/8/11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/1/11</td>
<td>Quantitative Data entered into SPSS</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt; researchers</td>
<td>Quantitative data entered, preliminary data cleaning and dichotomous coding completed</td>
</tr>
<tr>
<td>9/1/11</td>
<td>Quantitative data analyses conducted and results written</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt; researchers</td>
<td>Statistical assumptions performed and multiple regression analyses conducted for Research Questions 1 and 2</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/1/11</td>
<td>Qualitative data entered into Microsoft EXCEL and analyzed</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt; researchers</td>
<td>Qualitative data: Open coding and axial codes for response item number 11 was discussed and interpreted for Research Question 3. Axial codes include: Encouragement of Wonder/Curiosity Content-based Strategies Meta-cognitive Strategies Inquiry-based Strategies</td>
</tr>
<tr>
<td>8/1/11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/1/11</td>
<td>Qualitative data analyzed</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt; researchers</td>
<td>Qualitative data: Open coding and axial codes discussed and interpreted for each survey response item, 7-10 for Research Question 4. Axial codes include: Teacher Characteristics and Knowledge Props, Resources, Time and Materials Constructivism...Exploration, Inquiry, Observation, Discovery Science Relevance</td>
</tr>
<tr>
<td>11/1/11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/1/11</td>
<td>Qualitative data analyzed</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; and 2&lt;sup&gt;nd&lt;/sup&gt; researchers</td>
<td>Axial codes discussed and collapsed into initial selective themes for Research Question 3.</td>
</tr>
<tr>
<td>11/15/11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Task</td>
<td>Stakeholders</td>
<td>Notation</td>
</tr>
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<td>--------------</td>
<td>----------------------------------------------------------------------</td>
<td>----------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>11/15/11</td>
<td>Qualitative data analyzed</td>
<td></td>
<td>Initial selective themes include:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fostering Student Interest</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Teacher based Strategies that Encourage Student Questioning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Axial codes discussed and collapsed into initial selective themes for Research Question 4.</td>
</tr>
<tr>
<td>11/23/11</td>
<td></td>
<td>1st and 2nd</td>
<td>Initial selective themes include:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>researchers</td>
<td>Exploration of Science</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Life-long Science Learners</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Teacher Preparedness</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Instructional Method</td>
</tr>
<tr>
<td>11/24/11</td>
<td>Qualitative Data: Collapsed initial selective themes for Research</td>
<td></td>
<td>Final selective themes include:</td>
</tr>
<tr>
<td></td>
<td>Questions 3 and 4 into final selective themes</td>
<td>1st and 2nd</td>
<td>Teachers hold specific beliefs about what inquiry is in the elementary science classroom.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>researchers</td>
<td>Teachers hold specific beliefs about developing self-efficacy in the elementary science classroom.</td>
</tr>
<tr>
<td>12/01/11</td>
<td>Triangulation of quantitative and qualitative data</td>
<td>1st and 2nd</td>
<td>Discuss and develop table based on results from quantitative and qualitative analyses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>researchers</td>
<td>Plan, organize, detail and write including tables for implications for educational leaders, and implications for researchers</td>
</tr>
<tr>
<td>12/22/11</td>
<td>Chapter 5</td>
<td>1st and 2nd</td>
<td>Re-do Chapter 4’s quantitative results for Research Question 1, and the results section of Chapter 5 to include corrected current findings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>researchers</td>
<td>Following the return of the copies, researcher</td>
</tr>
<tr>
<td>1/13/12</td>
<td>Found mistake in quantitative data analyses. Conducted analyses a</td>
<td>1st and 2nd</td>
<td></td>
</tr>
<tr>
<td></td>
<td>second time, and found significance for second variable.</td>
<td>researchers</td>
<td></td>
</tr>
<tr>
<td>1/15/12</td>
<td>Final copy due to Advisor</td>
<td>researcher</td>
<td></td>
</tr>
<tr>
<td>2/15/12</td>
<td>Copies provided to Secondary Advisors</td>
<td>researcher</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Task</td>
<td>Stakeholders</td>
<td>Notation</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------</td>
<td>--------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3/31/12</td>
<td>Dissertation Defense</td>
<td></td>
<td>will make changes as directed by the advisor, and prepare for the dissertation defense</td>
</tr>
<tr>
<td></td>
<td>Data reports will be provided to principals</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Study results will be shared with all participants. (Spring 2012)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix N:

List of Open Code Responses and Related Axial Codes for

Survey Items 7 through 11
## Survey Item 7: How do good teachers teach science well?

<table>
<thead>
<tr>
<th>Survey Item Seven Responses</th>
<th>Codes for Survey Item 7 Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hands-on materials to investigate</td>
<td>6</td>
</tr>
<tr>
<td>Student's observations guide lessons</td>
<td>3</td>
</tr>
<tr>
<td>Students' questions guide lesson</td>
<td>3</td>
</tr>
<tr>
<td>Engage students in hands-on activities using scientific method</td>
<td>6</td>
</tr>
<tr>
<td>Allow students to explore and discover before providing definite terms/definitions</td>
<td>7</td>
</tr>
<tr>
<td>Allow children to create representations of what they have learned/understand</td>
<td>7</td>
</tr>
<tr>
<td>Inquiry based</td>
<td>7</td>
</tr>
<tr>
<td>Hands on</td>
<td>6</td>
</tr>
<tr>
<td>Children need opportunity to explore/ “discover” science</td>
<td>7</td>
</tr>
<tr>
<td>Hands-on experience</td>
<td>6</td>
</tr>
<tr>
<td>Use visuals</td>
<td>5</td>
</tr>
<tr>
<td>Allow students to research within the classroom</td>
<td>7</td>
</tr>
<tr>
<td>Answering essential questions</td>
<td>9</td>
</tr>
<tr>
<td>Provide hands-on experiences</td>
<td>6</td>
</tr>
<tr>
<td>Opportunities for exploration/discussions</td>
<td>7</td>
</tr>
<tr>
<td>Make experiences hands-on</td>
<td>6</td>
</tr>
<tr>
<td>Make experiences relevant</td>
<td>8</td>
</tr>
<tr>
<td>Make experiences interesting</td>
<td>2</td>
</tr>
<tr>
<td>Teach to the student’s interests-allowing for the content to be geared (when possible) so they have choice</td>
<td>2</td>
</tr>
<tr>
<td>Teach in a variety of methods-visual, hands-on, oral, reading</td>
<td>1</td>
</tr>
<tr>
<td>Ask questions</td>
<td>9</td>
</tr>
<tr>
<td>Provide students with opportunities to experiment and discover</td>
<td>7</td>
</tr>
<tr>
<td>Use the scientific method</td>
<td>7</td>
</tr>
<tr>
<td>Incorporate hands-on experiments</td>
<td>6</td>
</tr>
<tr>
<td>Survey it</td>
<td>7</td>
</tr>
<tr>
<td>Create inquiry-based learning experiences</td>
<td>7</td>
</tr>
<tr>
<td>They have solid understanding of the content being taught</td>
<td>10</td>
</tr>
<tr>
<td>They offer hands-on projects</td>
<td>6</td>
</tr>
<tr>
<td>Lead their students through inquiry-based learning</td>
<td>7</td>
</tr>
<tr>
<td>Pose questions.</td>
<td>9</td>
</tr>
<tr>
<td>Provide materials for exploration</td>
<td>6</td>
</tr>
<tr>
<td>More opportunity for questions</td>
<td>9</td>
</tr>
<tr>
<td>Try new things to try to figure out questions</td>
<td>9</td>
</tr>
<tr>
<td>Inquiry based.</td>
<td>7</td>
</tr>
<tr>
<td>Teach kids to observe their world and wonder.</td>
<td>7</td>
</tr>
<tr>
<td>Hands on experiences</td>
<td>6</td>
</tr>
<tr>
<td>Hands-on experiences including writing (detailed, descriptive language when recording observations etc.)</td>
<td>6</td>
</tr>
<tr>
<td>Hands-on experiences including Math (recording &amp; analyzing data etc.)</td>
<td>6</td>
</tr>
<tr>
<td>Encouraging observation throughout the curriculum; essential science skills</td>
<td>7</td>
</tr>
<tr>
<td>Encouraging inquiry throughout the curriculum</td>
<td>7</td>
</tr>
<tr>
<td>Also vital ...emphasis on providing evidence for opinions in all areas</td>
<td>7</td>
</tr>
<tr>
<td>Within science itself, encourage an interest in how the world works, through our passion/enthusiasm</td>
<td>7</td>
</tr>
<tr>
<td>Yes, labs work</td>
<td>6</td>
</tr>
<tr>
<td>I run a summer science lab; would love to teach science-centered curriculum all year</td>
<td>6</td>
</tr>
<tr>
<td>They[teachers] have a strong background.</td>
<td>4</td>
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<tr>
<td>Open to continue learning</td>
<td>4</td>
</tr>
<tr>
<td>Appreciate questioning</td>
<td>9</td>
</tr>
</tbody>
</table>
Use an inquiry-based model
Provide students with opportunities to think
Provide students with opportunities to wonder
Provide students with opportunities to research
Provide students with opportunities to discover
Provide students with opportunities to apply ideas related to scientific inquiry
Start with a question – this will give a focus for the lesson.
Make as much of the lesson hands-on.
Provide opportunity for self discovery.
Know the subject and/or content of what you teach.
Allow for exploration.
Foster questioning, hypothesizing and testing hypothesis.
Using a hands-on approach.
Discovery
Hands-on.
“Big Questions” to answer,
Opportunities to ask questions
Collaborate
Perform authentic research.
Hands-on materials
If you can teach, it is my belief that you can teach anything
Showing enthusiasm is a plus
Showing knowledge is a plus
Use experiments
Collaboration
Hands-on learning
Scientific method
Observation
Field trips to teach science
Teach the scientific method
Hands-on experiments 6
Group work 7
Teachers understanding 4
Feeling comfortable with the content 4
Prepare the students with interesting conversation to draw them in 2
Hands-on use of materials 6
Have kids explain their thinking 3
Log information learned in journals 3
Student engagement through hands-on activities 6
Inquiry based approach to learning 7
Hands on 6
I feel experiments and inquiry approach is the best way to teach 7
By engaging the students w/hands on activities 6
Knowing their material, 4
Hands on activities 6
With a professional developer 11
Doing the science. 7
Allow students to learn through inquiry 7
Teaching supported by research 4
Understand the curriculum components 4
Make science relatable and come to life for their students 8
Getting to know curriculum well by experiencing it themselves. 4
A great program from which to develop an inquiry based program. 7
Science should be taught with hands- 6
Authentic learning experiences. 8
After an introduction of background information, science should be hands-on (depending upon the topic 6
Inquiry – based lessons 7
Hands on experiments to maximize student engagement. 6
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>With critical &amp; creative thinking</td>
<td>7</td>
</tr>
<tr>
<td>Allowing students to ask questions</td>
<td>9</td>
</tr>
<tr>
<td>[Allowing students to] use manipulatives when necessary</td>
<td>6</td>
</tr>
<tr>
<td>Promote hands-on</td>
<td>6</td>
</tr>
<tr>
<td>Teach good wonderings and predictions</td>
<td>7</td>
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<tr>
<td>Draw conclusions</td>
<td>4</td>
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<tr>
<td>Show a passion for science</td>
<td>7</td>
</tr>
<tr>
<td>Hands on activities</td>
<td>6</td>
</tr>
<tr>
<td>When children figure out or discover something, they will remember the concept</td>
<td>7</td>
</tr>
<tr>
<td>Hands-on, discovery based learning develops an interest (hopefully a love) of science</td>
<td>6</td>
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<tr>
<td>Discovery based learning develops an interest (hopefully a love) of science</td>
<td>7</td>
</tr>
<tr>
<td>Hands-on experiments</td>
<td>6</td>
</tr>
<tr>
<td>Connect to everyday life</td>
<td>8</td>
</tr>
<tr>
<td>Collect snow and melt for states of matter.</td>
<td>6</td>
</tr>
<tr>
<td>Teach methodology language, e.g., hypotheses, theory methods results</td>
<td>6</td>
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<tr>
<td>Provide hands-on experiments/experiences</td>
<td>6</td>
</tr>
<tr>
<td>Clear expectations/goals</td>
<td>3</td>
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<tr>
<td>Investigate questions that interest students.</td>
<td>9</td>
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<tr>
<td>Utilize scientific method</td>
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<tr>
<td>Provide hands on experiences</td>
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</tr>
<tr>
<td>Encourage students to use the scientific method.</td>
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<tr>
<td>Hands-on</td>
<td>6</td>
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<tr>
<td>Discovery</td>
<td>7</td>
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<tr>
<td>Multi-disciplinary</td>
<td>12</td>
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<tr>
<td>Combining hands on/experiments, vocabulary &amp; reading.</td>
<td>6</td>
</tr>
<tr>
<td>Utilizing hands-on experiments</td>
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<tr>
<td>Teach all procedures of the scientific method when completing experiments</td>
<td>6</td>
</tr>
<tr>
<td>Have enough time to do “hands-on” activities</td>
<td>6</td>
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</tbody>
</table>
Science is taught through exploration
“Hands on”
Becoming active participants in the process.
Hands-on experiments
Being an active part of scientific process.
Hands-on/multisensory subject
Students have to opportunity to ask questions
Make discoveries about their world
Ask lots of questions?
Follow the scientific method.
Give students opportunities for hands on projects done in class
Make elementary science engaging and relevant
Use as much hands on learning as possible
Engage students in thoughtful observation
Actively engage students
Guide students [to] draw conclusions.
Help students draw conclusions.
Connect science to the world around them
Take kids outside to observe nature
Physical experiments in class
Life science experiments in class
Connect science to literature
Connect science to current events
Review standards
Review our district’s performance indicators
Gather appropriate objectives for each lesson
Create lessons
Create unit
Lecture
Hands on. 6
Hands on experience 6
Experimentation 7
Children need lots of hands-on experiences 6
Children need lots of concrete experiences 6
As many multisensory lessons as possible 6
Integrating science activities/lessons throughout a day as opposed to a science – I believe works best for young learners 4
Hands-on experience 6
Making science out of everyday experiences 8
Connecting science with other subject areas 12
By teaching it hands-on 6
They incorporate questioning 9
Allow for student exploration while integrating other subject areas. 7
Use hands-on materials 6
Relate it to real-life things students know about 8
Integration with all subject areas 12
Creativity 7
Use manipulatives 5
Materials should also cross many subjects; math, writing, culture 12
Being passionate about the topic 4
Using an investigative style with hands-on activities 7
Allow students hands-on opportunities to experiment 6
Allow students hands-on opportunities to test hypotheses 6
Allow students hands-on opportunities to discover 6
Provide hands-on experiences 6
Inquiry-based 7
Students see how it applies in the world around them 8
Self-learning 4
Some degrees of teacher input  4
Using inquiry-based teaching  7
Having background knowledge  4
Having and sharing background knowledge  4
Manipulatives  5
Consistency  4
Standards to follow  3
Demonstrate a passion for science  4
Encourage scientific method  6
Keep it hands-on  6
Demonstrate how to do activity  4
Be explicit in directions  4
Hands-on activities  6
Make it fun  2
Concrete  7
Hands-on activities;  6
Teachers "appreciate questioning" and another stated that  3
Manipulatives  5
Incorporate it into other subjects  12
Make it fun and engaging  6
Get background knowledge on the subject  4
Integrate components of Science in the curriculum each day  12
Enthusiasm;  4
Modeling;  4
Demonstration;  4
Prepare;  4
Provide hands-on opportunities  6
Using a lot of hands-on activities that let kids use their minds  6
With demonstrations;  1

Integrate science into the curriculum; 12
Workshops; 1
By modeling; 1
Understanding the topic to answer questions; 4
Hands-on experiments 6
Through frequent inquiry 7
Hands-on experience 6
Through inquiry 7
By giving student the chance to explore using materials 7
Inquire what students know [about] subject to be studied in science 3
Questions they have on subject 9
Hands-on materials; 6
Experiments; 7
Connections to everyday life experiences; 8
Connecting to their background knowledge

[Use] experiments
Hands-on experiences
With a lot of hands-on activities
Integrate it across the curriculum;
Hands-on teaching
Engage children
Encourage them to explore.
Predict
Observe;
Push higher level thinking skills
Encourage them to ask questions
Explain their thinking in a way others would understand
Hands-on-learning i.e. Experiments
Exploration
With a hands-on-approach
By using different modalities of instruction, hands-on
By using different modalities of instruction, demonstration,
By using different modalities of instruction, teacher-directed,
Hands-on approach
Make things as concrete as possible
Offering hands-on activities with discussions that allow students to test ideas
Offering experiential activities with discussions that allow students to test ideas
Inquiry-based program[Science 21] encourages students to think like a scientist.
Students are also encouraged to take risks
[Students encouraged to] ask questions
[Students] involved in identifying problems
[Students] finding solutions
They evaluate the solutions 3
Check for understanding using spoken words 3
Check for understanding using written words 3
Check for understanding using a wide variety of forms 3
Hands-on 6
Excitement 4
Motivation 4
When students are encouraged to ask questions in a particular areas 9
[Students] allowed to explore the answers tactility 7
With enthusiasm! Find a way to have an interest in the topic yourself generally allows for a better /well thought out lesson... Motivating to young students 4
Find a way to have curiosity about the topic yourself generally allows for a better /well thought out lesson... Motivating to young students 4
Encouraging questions 6
Encouraging observations 9
Encouraging thinking 4
If this isn’t coming up naturally, find a way to generate it 4
Ask inquiry-based questions 9
Encourage hands-on experiences 6
Lots of discussions with partners to share observations and ideas 7
Using experiences 7
Things that occur; 7
Working “like scientists” 6
Let children explore 7
<table>
<thead>
<tr>
<th>Initial Selective Themes for Survey Response Item Seven</th>
<th>Total Number of Codes for Survey Item 7 by Theme</th>
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<tbody>
<tr>
<td>1 - Learning Styles /Teacher Delivery Styles</td>
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<td>2 - Interesting Experiences/Enjoyment</td>
<td>5</td>
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<tr>
<td>3 - Formative Assessment</td>
<td>15</td>
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<tr>
<td>4 - Teacher Characteristics and Knowledge</td>
<td>41</td>
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<tr>
<td>5 - Props, Resources, Time and Materials</td>
<td>47</td>
</tr>
<tr>
<td>6 - Hands-On Opportunities for Learning-Scientific Method</td>
<td>90</td>
</tr>
<tr>
<td>7 - Constructivism, Exploration, Inquiry, Observation, Discovery</td>
<td>83</td>
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<tr>
<td>8 - Science Relevance</td>
<td>11</td>
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<tr>
<td>9 - Questioning</td>
<td>21</td>
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<tr>
<td>10 - Science Content</td>
<td>14</td>
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<tr>
<td>11 - Teacher Collaboration</td>
<td>4</td>
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<tr>
<td>12 - Multi-Disciplinary</td>
<td>13</td>
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<tr>
<td>13 - Don't Understand</td>
<td>13</td>
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<tr>
<td>Total</td>
<td>353</td>
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</table>
Survey Item 8: Are there any experiences outside the classroom that you believe have increased your effectiveness as a classroom teacher?

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<tr>
<th>Survey Item 8 Responses</th>
<th>Codes for Survey Item 8 Responses (continued)</th>
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<tbody>
<tr>
<td>Botanical Gardens/GNC field trips have taught teacher things to do “in house”</td>
<td>4</td>
</tr>
<tr>
<td>Visits to museums, nature centers</td>
<td>4</td>
</tr>
<tr>
<td>Visits to nature centers, other climates and habitats</td>
<td>4</td>
</tr>
<tr>
<td>Gardening</td>
<td>2</td>
</tr>
<tr>
<td>Yes, my own curiosity and desire to know how/why/way things work</td>
<td>3</td>
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<tr>
<td>Having done poorly as a science student has propelled me to teach well</td>
<td>3</td>
</tr>
<tr>
<td>More I educated myself</td>
<td>5</td>
</tr>
<tr>
<td>Botanical Gardens on my own</td>
<td>4</td>
</tr>
<tr>
<td>I go to museums/aquariums in every state I visit in to increase my knowledge of Seashore</td>
<td>4</td>
</tr>
<tr>
<td>Science curriculum</td>
<td>4</td>
</tr>
<tr>
<td>Habits of Mind Workshop</td>
<td>6</td>
</tr>
<tr>
<td>Awe and wonderment</td>
<td>3</td>
</tr>
<tr>
<td>Posing questions</td>
<td>3</td>
</tr>
<tr>
<td>Use all their outside experiences in their classrooms. Going on a hike…find things in your classroom</td>
<td>4</td>
</tr>
<tr>
<td>Having animals as pets has helped me to be more effective, since I am a better observer</td>
<td>2</td>
</tr>
<tr>
<td>Took a course on Science Journals; valuable sharing tool for students</td>
<td>6</td>
</tr>
<tr>
<td>Professional development.</td>
<td>6</td>
</tr>
<tr>
<td>Visit other schools to see what they are using.</td>
<td>4</td>
</tr>
<tr>
<td>Participated in a science workshop at IBM in Briarcliff</td>
<td>6</td>
</tr>
<tr>
<td>Experiences at BOCES</td>
<td>6</td>
</tr>
<tr>
<td>With sustainability training field trips to Madden [Outdoor Education facility by BOCES]</td>
<td>4</td>
</tr>
<tr>
<td>Field trips to Morse Estate</td>
<td>4</td>
</tr>
<tr>
<td>Field trips to museums</td>
<td>4</td>
</tr>
<tr>
<td>Guest scientists</td>
<td>4</td>
</tr>
</tbody>
</table>
All outside experiences shape my fundamental teaching skills

Field trips
Science training
Visiting science centered museums
Reading NY times
Classroom trips
Trips to the Zoo have helped with my animal studies in 2nd grade
have listened to the children’s questions/comments about science & created lessons around that
Watching Discovery Channel, etc.
Getting DVD’s from the Discovery Store and use for note-taking and other curricular skills
and just plain enjoyment (increases curiosity about the world around us)
STI classes, [teacher center classes shared by 2 districts]
Workshops
Conferences.
N/A
[Visiting] aquariums, etc.
New York Botanical Gardens Summer Science ED workshops “Seeds/Plants, Earth Science – Summer
Yes, field trips i.e. When we study pond life, we go and visit a pond ecosystem
Our field trips to the Nature Center and mine have brought these units to life
Professional development in inquiring based education
Work on district inquiry committees/presentations
Frequent visit to the NY Botanical Gardens
I enjoy science programs: Nova, Radio Lab, Science Friday
Working in a garden
Our trips to the Bronx Zoo have helped with experiences outside the classroom
Observations of other teacher’s lessons
Life experiences involving science and scientists
I attended workshops 6
I have a masters degree in elementary school science education 5
Teach science to 3 – 6 year olds at a summer camp 7
Raising my sons and teaching them, eg, solar system using pots and pans 7
Field trips 4
Field trips 4
Interest in nature (flowers/pets) 3
At Ward – The sound water 6
Saturdays 7
Work on the Green Initiative outside the classroom 7
My experience w/literary/questioning 2
Having the children be weather reporters 9
Just my interest in science 3
Listening to others 6
Learning ideas from co-workers 6
“Borrowing” ideas from co-workers 6
“Borrowing” ideas from co-workers 6
I love hiking 2
Have travelled to Costa Rica 4
Any time I ‘connect with nature” it enhances my excitement about science 3
Learned great content about the rainforest [Costa Rica] 5
Great experience at “Natures Classroom” in Massachusetts 6
Camping Trips as a young adult 2
Being a creative cook 2
Taking my own children to science museums 4
Course at Iona College that was very hands on 6
Being a thoughtful, curious person -nothing specific 3
Read the Science Times share with students 5
Read other articles and share with students 5
Visit other Colleagues
View online resources 5
Not yet – but plan to take a science course @ Iona to enhance science instruction 9
Field trips 4
Attending museums 4
Movies 5
Reading 5
Museum trips 4
Being a mom 3
Yes – having my house hit by lightning through a whole new sense of reality to “science” 5
Going to Nature’s Classroom with my students 4
Extreme weather we have been experiencing has opened many opportunities for meaningful discussions because the children are living it 5
Yes- Teacher Source.com. 5
Safari Montage available in class 5
Yes- Having the nature center right next to the school 4
Taking field trips to places such as Peabody 4
Taking field trips Garbage Museum 4
Taking field trips Science Center 4
Gardening 2
Gardening at home 2
Yes- Last year I had the opportunity to help create a butterfly garden 2
It helped me to appreciate butterflies 3
It helped me to teach about butterflies in real life instruction 5
Strong interest in meteorology 5
Having a home weather station helped me show students how cool science is 5
Workshops at Talcott Mt. Science Center 4
Involvement with community nature centers 4
Shows like the PBS Nature series 5
Travel
Personal experience with animals
Personal experience with plants
Talking with other teachers
Yes, teaching science during the summer
Reading articles
Trying hands-on myself
Look at most of my everyday experiences inquisitively which in return comes back to the classroom
Nature’s Classroom yearly field trips
Working with other teachers
Going on field trips
Nature walks
Museums
Trout in classroom
Camp counselor
Taken classes with Project Learning Tree
Natural interest in animals
Natural interest in nature
Reading “Last Child in the Woods”
In high school, I enjoyed science;
I teach at a summer science camp
Field trips
Trout in the classroom
Boots and Shoots
Natural trail walks
Field trips
Taking science courses
Going to zoos and aquariums
Yes, attending science classes at Sacred Heart University (Eisenhower Grant) 6
Use both science and language arts classes to integrate within the curriculum 5
Vacations 2
Experiences 4
Outdoor activities 4
Classes taken 6
Just doing a lot of activities with my family 2
Seeing my children’s interest 7
My interest in nature 2
Outdoor activities 2
My daughter’s involvement in science program at WestConn 3
My daughters’ science fairs K-7 at their school 3
Visiting museums 4
Visiting nature centers 4
Visiting science museums 4
Visiting zoos 4
Visiting aquariums 4
Watching shows 2
Visiting people who are science teachers who share great ideas and energy 6
Having an inquisitive son 3
[Worked in] Summer science program [as] aide in classroom for 2 years 7
Visits to science museums 4
Field trips 4
Having very curious children who are constantly asking questions 3
Traveling 2
Taking a field trip 4
Traveling 2
Through professional development; 6
Outside workshops 6
<table>
<thead>
<tr>
<th>Activity</th>
<th>Count</th>
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<tbody>
<tr>
<td>Hands-on experiences</td>
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<tr>
<td>Reading</td>
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<tr>
<td>College, I took a “Teaching Science” course</td>
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<tr>
<td>Hands-on experiences with students</td>
<td>4</td>
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<tr>
<td>Trial and error</td>
<td>3</td>
</tr>
<tr>
<td>As a second year teacher, I find that by reflections on my lessons, I am able to increase my effectiveness</td>
<td>3</td>
</tr>
<tr>
<td>Personal visits to science museums</td>
<td>4</td>
</tr>
<tr>
<td>Reading on my own to learn about new things</td>
<td>5</td>
</tr>
<tr>
<td>Yes-nature’s classroom</td>
<td>4</td>
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<tr>
<td>Class visits to Science Centers in Hartford</td>
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<tr>
<td>Hands-on science</td>
<td>4</td>
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<tr>
<td>Slippery stones</td>
<td>4</td>
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<tr>
<td>Reading on subjects that interest my grandchildren</td>
<td>5</td>
</tr>
<tr>
<td>Places I have visited such as science museums</td>
<td>4</td>
</tr>
<tr>
<td>Learning with my own children</td>
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<tr>
<td>Discovering with my own children</td>
<td>3</td>
</tr>
<tr>
<td>Visits to museums</td>
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<tr>
<td>[Visit] nature centers</td>
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<tr>
<td>Walks through the neighborhood</td>
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<tr>
<td>Field trips</td>
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<tr>
<td>Speakers</td>
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<tr>
<td>Participation in activities to enhance the learning</td>
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<tr>
<td>We took a field trip to the Maritime Aquarium</td>
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<tr>
<td>Workshops at Columbia Teacher’s College</td>
<td>6</td>
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<tr>
<td>Field trips</td>
<td>4</td>
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<tr>
<td>An elective science course at Pace University geared toward teachers</td>
<td>6</td>
</tr>
<tr>
<td>Outside workshops i.e. Science 21 workshops</td>
<td>6</td>
</tr>
<tr>
<td>Chicken workshops</td>
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</tr>
</tbody>
</table>
Sure, my own interests in Nature 2
Gardening 2
Animals 2
Since I teach earth science, I have visited volcanoes in Greece and Italy and brought home 4
“souvenirs” for my class
There has also been a lot of earth science news recently
My appreciation in inquiry of the world around me (nature, fishing, etc.) 3
My interest in inquiry of the world around me (nature, fishing, etc.) 2
Museum visits with my own children 4
Science 21 training 6
Life-long learner 3
All my life experiences have helped to make me a better classroom science teacher-
Nature walks 2
Science journals 5
I simply find science interesting 3
Practice, practice 9
No 9
I am very comfortable with science 3
[I ]regularly pursue science reading and questions 5
Curiosity about the world and bringing that in to my students 3
And bringing that[curiosity] in to my students 3
Finds from the natural world 2
Science Times articles brought to their level 5
Interesting museum trips 4
Interesting photo 2
Interesting interest in animals 2
Field trips (ex. Gedney Park Pond study) 4
Training on specific units through BOCES Programs 6
Loving animals 2
<table>
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<tr>
<th>Initial Selective Themes for Survey Response Item Eight</th>
<th>Total Number of Codes for Each Theme</th>
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<tbody>
<tr>
<td>1 - Learning Styles - Teacher Delivery styles</td>
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<tr>
<td>2 - Non-school science related experiences (hobbies)</td>
<td>43</td>
</tr>
<tr>
<td>3 - Teacher Characteristics</td>
<td>27</td>
</tr>
<tr>
<td>4 - Travel to Other Places</td>
<td>72</td>
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<tr>
<td>5 - Knowledge advancement</td>
<td>36</td>
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<tr>
<td>6 - Professional development</td>
<td>38</td>
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<tr>
<td>7 - Non-school science related teacher experiences</td>
<td>9</td>
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<tr>
<td>8 - Collaboration</td>
<td>0</td>
</tr>
<tr>
<td>9 - Don't understand</td>
<td>8</td>
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<tr>
<td>Total</td>
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### Survey Item 9: What do you think you do well when you are teaching science?

<table>
<thead>
<tr>
<th>Survey Item 9 Responses</th>
<th>Codes for Survey Item 9 Responses</th>
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<tbody>
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<td>Not teaching science this year</td>
<td>12</td>
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<tr>
<td>Engage students</td>
<td>10</td>
</tr>
<tr>
<td>Get them excited about a topic</td>
<td>10</td>
</tr>
<tr>
<td>Access prior knowledge and relate it to their everyday lives</td>
<td>7</td>
</tr>
<tr>
<td>I show sincere interest and enthusiasm for science learning</td>
<td>3</td>
</tr>
<tr>
<td>Ask questions that generate discussion</td>
<td>8</td>
</tr>
<tr>
<td>Use experimentation to aid in answering those questions</td>
<td>6</td>
</tr>
<tr>
<td>I ask questions</td>
<td>8</td>
</tr>
<tr>
<td>Allow children the opportunity to explore</td>
<td>6</td>
</tr>
<tr>
<td>I ask questions that make students wonder/think about the topic</td>
<td>8</td>
</tr>
<tr>
<td>I allow for a lot of thought-not just “read and respond”.</td>
<td>6</td>
</tr>
<tr>
<td>Allow children to experiment and explore without too many limitations</td>
<td>6</td>
</tr>
<tr>
<td>Show that I value their ideas as they share their discoveries with their friends</td>
<td>3</td>
</tr>
<tr>
<td>Creating experiences where students can take trips, see things for themselves, touch things, manipulate materials</td>
<td>6</td>
</tr>
<tr>
<td>Provide lots of hands-on learning</td>
<td>5</td>
</tr>
<tr>
<td>Provide opportunities for students to explore their own questions about the world around them</td>
<td>6</td>
</tr>
<tr>
<td>Share my excitement with students</td>
<td>3</td>
</tr>
<tr>
<td>Push them to question and wonder</td>
<td>6</td>
</tr>
<tr>
<td>Provide materials</td>
<td>4</td>
</tr>
<tr>
<td>To make a mess with and discover new things!</td>
<td>6</td>
</tr>
<tr>
<td>Teaching science via language arts</td>
<td>11</td>
</tr>
<tr>
<td>Inspiring inquiry and enthusiasm</td>
<td>3</td>
</tr>
<tr>
<td>Asking higher level and inferential thinking questions</td>
<td>8</td>
</tr>
<tr>
<td>Give up control!!!</td>
<td>3</td>
</tr>
<tr>
<td>Create an environment for children to think “out of the box”</td>
<td>6</td>
</tr>
</tbody>
</table>
I emphasize process
I encourage asking questions as opposed to providing answers
I follow the children’s questions and interests
I love Science
Students get excited because they see how excited I am
Hands-on experiences are thrilling for students
EVERYTHING – but most important is to spark their interest
Find out what prior knowledge they have of the subject
Posing questions
Supporting kids in asking their own questions and searching for answers
Use Visual aid
Hands-on materials
Literature
Exploration
Hands-on activities
I provide students the chance to create experiments
Use scientific method
Work together with partners and groups
I also use the Smartboard to enhance learning
Use literature to engage students
Use videos to engage students
Show enthusiasm towards learning
Teaching the fundamental scientific method which will shape the student’s future science experiences
Facilitating my students to explore
Facilitating my students to make observations and predictions
Experimenting & discovery
Making connections to everyday life
Gaining student engagement and participation
<table>
<thead>
<tr>
<th>Activity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hands-on learning.</td>
<td>5</td>
</tr>
<tr>
<td>Generate excitement and curiosity.</td>
<td>10</td>
</tr>
<tr>
<td>Have students ask good questions.</td>
<td>8</td>
</tr>
<tr>
<td>I always have a memorable, hands-on activity.</td>
<td>5</td>
</tr>
<tr>
<td>Create curiosity</td>
<td>10</td>
</tr>
<tr>
<td>Foster creative and critical thinking</td>
<td>6</td>
</tr>
<tr>
<td>Teaching how to work a detailed procedure.</td>
<td>6</td>
</tr>
<tr>
<td>Determining a manipulated variable, controlled variables, conclusions</td>
<td>5</td>
</tr>
<tr>
<td>I show my enjoyment and excitement.</td>
<td>3</td>
</tr>
<tr>
<td>I also allow students to discover content independently.</td>
<td>6</td>
</tr>
<tr>
<td>Integrating science content across the curriculum.</td>
<td>11</td>
</tr>
<tr>
<td>Model ways to use creative &amp; critical thinking.</td>
<td>6</td>
</tr>
<tr>
<td>Discover with them.</td>
<td>6</td>
</tr>
<tr>
<td>Use a variety of teaching strategies such as: using visuals, hands-on experiences, technology, research, media</td>
<td>4</td>
</tr>
<tr>
<td>Reach all of the students learning styles.</td>
<td>1</td>
</tr>
<tr>
<td>Very passionate in the curriculum I teach, so I think the students are more engaged as well</td>
<td>3</td>
</tr>
<tr>
<td>Very interested in the curriculum I teach, so I think the students are more engaged as well</td>
<td>3</td>
</tr>
<tr>
<td>Get kids engaged/excited in subject matter</td>
<td>10</td>
</tr>
<tr>
<td>Student –centered lessons</td>
<td>10</td>
</tr>
<tr>
<td>Based lessons on student driven lines of inquiry.</td>
<td>6</td>
</tr>
<tr>
<td>Encourage thinking</td>
<td>6</td>
</tr>
<tr>
<td>Provide opportunities for kids to explore</td>
<td>6</td>
</tr>
<tr>
<td>[Provide opportunities for kids] to experiment</td>
<td>5</td>
</tr>
<tr>
<td>[Provide opportunities for kids]to predict</td>
<td>5</td>
</tr>
<tr>
<td>[Provide opportunities for kids]to observe</td>
<td>5</td>
</tr>
<tr>
<td>I enjoy the labs</td>
<td>3</td>
</tr>
</tbody>
</table>
Really good science experiments 5
Lead the class in great discussions 3
Motivating children 10
Promoting divergent thinking 6
[Promoting] further questioning 8
Teach them to notice deeply 6
I get the students excited by the activity 3
Present them with activities they enjoy doing and learn from 3
Teach science to 3 – 6 year olds at a summer camp 12
Allow them to do all experiments on their own; Every young child wants to do everything in an experiment and I allow them to 3
Connecting to personal experiences 10
Ask higher level questions 8
Connect to other subjects 11
Incorporate technology 4
Make connections to other subject areas 11
Use technology 4
Let students experiment 5
Hands-on 5
Enthusiastic 3
Asking questions 8
Vocabulary & development***** 12
Experiments 5
Literature in to math 11
Utilize technology (ex. Smartboard) 4
Have the children work in cooperative groups 10
Use good questioning techniques 8
Ask many questions 8
| Planning interesting experiments | 10 |
| Planning interesting activities |  |
| I think I can take a topic and find creative ways to enforce a concept through arts and crafts | 4 |
| Find creative ways to enforce a concept - use of Food – things that really grab kids interest | 4 |
| Previous experience as an art teacher helps me to teach in a way that allows for exploration of materials | 3 |
| Creating problems with more than one solution | 6 |
| Give students a change to keep a science journal for reflection | 2 |
| Spark curiosity | 10 |
| Encourage thinking out of the box | 6 |
| Encourage students to try new things | 6 |
| Experimenting | 5 |
| Bring the topics down to the level of which the students can understand | 10 |
| Constantly review prior topics covered before moving on | 2 |
| Make it relevant to their lives. | 7 |
| Integrate more technology | 4 |
| Ask good questions | 8 |
| Make connections between our content and other areas of the curriculum/life | 11 |
| Connect it to real world | 7 |
| Pose questions | 8 |
| Have kids pose questions | 8 |
| Get students engaged | 10 |
| Teach objective, | 2 |
| Accomplish goal | 2 |
| Explain | 7 |
| Guide | 10 |
| Work through step by step | 10 |
Create an environment safe 3  
Create an environment free to make mistakes 3  
Create an environment free to explore 3  
Creating science Lab Sheets is a must for students to record process. 4  
Develop enthusiasm 3  
Allow hands on activities 5  
Good vocabulary base***  
Good observation lessons 6  
Good base of reading materials 4  
I like science – so I have enthusiasm. 3  
Letting kids discover concepts on their own 6  
Letting kids “play” while learning science  
Keep the students’ attention 100% of the time! 6  
“Science is Fun!” I keep saying it because they haven’t all had that kind of experience. 3  
I love doing different experiments 3  
Watching the kids observe “real life” 6  
Seeing their conclusions 6  
Using hands-on materials 4  
Using visuals 4  
Immerse my students in the topic we are studying 6  
I can be very animated 3  
I can be very explicit 3  
Engage my students by helping them make connections with their experiences 10  
Using hands-on activities 5  
[Hands-on activities] helps my students become excited about science 5  
Get the children excited about the topic 10  
Try to have as many hands-on activities as I can 5  
Share feeling that this is important 7  
Share feeling that this relevant to students’ world 7
Modeling 10
Speaking slow 10
Allowing students time to experiment 4
Making the kids excited to explore 10
Make them responsible for their inquiry 6
They are confident enough to explore 10
They are confident enough to try more 10
Looking at each discovery through the students’ “eyes” 3
Looking at each discovery through the students’ "minds" 3
I can better understand their needs so they can feel comfortable with the
unpredictability of science from their perspective 3
Modeling 10
Providing hands-on experiences for the students 5
Getting the students involved 6
Buying our own materials 4
Encourage students to brainstorm 6
Bring the materials to life 4
Encourage discourse 6
Very explicit showing how to do the activities 6
I try to model what I want the students to do 3
Mix of lecture (not much) and hands-on learning 5
Show appropriate videos to enhance learning 4
Show excitement 3
Have living specimens 4
Materials 4
Create an experience they will remember 3
Engage the students 10
The children respond positively 12
Children are like sponges. They want more 12
Providing field trip experiences (outside the school) are beneficial 4
Providing field trip experiences (inside school) are beneficial 4
Bring a love of the topic to the student 3
Provide hands-on opportunities 5
Let the kids run all the experiments 5
Clarity of topic 10
Promethean activities 6
Hands-on activities 5
Relevant field trips 4
In-school activities 4
Teach the vocabulary********
Teaching students to think like scientists; Repeat [do it all over again] 5
Observe 6
Question 8
Wonder 6
Sketch 6
Come up with a theory 6
Repeat [do experimentation and theory building all over again] 6
Having a clear objective for each session 10
Encouraging kids to ask questions 8
Having children observe 6
[Children] come up with “theories” before telling or teaching 6
Using all the senses 6
Write about…, Draw about…, Tell someone about…’ 6
Give the kids time to learn 4
Explore 6
Sketch 6
Become scientists 6
Letting children come up with theories 6
<table>
<thead>
<tr>
<th>Topic</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hands-on experiments</td>
<td>5</td>
</tr>
<tr>
<td>Modeling</td>
<td>10</td>
</tr>
<tr>
<td>Explanations</td>
<td>7</td>
</tr>
<tr>
<td>Very hands on</td>
<td>5</td>
</tr>
<tr>
<td>Manipulative</td>
<td>5</td>
</tr>
<tr>
<td>Many examples</td>
<td>7</td>
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<tr>
<td>Many questions</td>
<td>8</td>
</tr>
<tr>
<td>Allow students to have choice;</td>
<td>1</td>
</tr>
<tr>
<td>[Allow students to] explore on their own</td>
<td>6</td>
</tr>
<tr>
<td>Giving the students the chance to use inquiry method</td>
<td>6</td>
</tr>
<tr>
<td>Follow the scientific method of inquiry</td>
<td>6</td>
</tr>
<tr>
<td>Integrating science across the curriculum;</td>
<td>11</td>
</tr>
<tr>
<td>Incorporating journals;</td>
<td>10</td>
</tr>
<tr>
<td>Reading about a topic;</td>
<td>10</td>
</tr>
<tr>
<td>Exploring math concepts that connect</td>
<td>11</td>
</tr>
<tr>
<td>I enjoy doing experiments;</td>
<td>3</td>
</tr>
<tr>
<td>Have students participating in experiments</td>
<td>10</td>
</tr>
<tr>
<td>Discussions</td>
<td>10</td>
</tr>
<tr>
<td>Providing the literature, non-fiction texts to support</td>
<td>11</td>
</tr>
<tr>
<td>I create an enthusiastic atmosphere</td>
<td>3</td>
</tr>
<tr>
<td>Get students excited;</td>
<td>10</td>
</tr>
<tr>
<td>Keep[students] engaged</td>
<td>10</td>
</tr>
<tr>
<td>Let kids predict</td>
<td>5</td>
</tr>
<tr>
<td>Encourage them to explain their thinking in a clear way</td>
<td>6</td>
</tr>
<tr>
<td>Experiments w/ kids</td>
<td>5</td>
</tr>
<tr>
<td>Access prior knowledge before beginning science unit</td>
<td>7</td>
</tr>
<tr>
<td>Giving students time to formulate their own questions about experiment</td>
<td>8</td>
</tr>
<tr>
<td>Let the children explore</td>
<td>6</td>
</tr>
</tbody>
</table>
Let the children enjoy 6
Let the children ask questions 8
Explain concepts 10
Have students draw conclusions 6
I give the children time for free exploration 6
Generating excitement 3
Since I always wonder about something, I relate easily to children who are naturally curious 3
I encourage them to listen to their questions 8
I encourage them to take the next steps 3
Really know the material; 3
Get kids to ask questions 8
Keep an open mind 3
Encourage students to find their own answers 6
Able to explain science concepts in concrete terms 3
Give the students the hands-on-experiences necessary to understand them intuitively 5
Allowing students to ask their own questions 8
Finding out the answers together 6
What do you know, and what do you want to know 8
Ask them to explain their own thinking 6
Encourage them to explain their own thinking 6
Organize materials needed 4
Encourage more partner inquiry rather than “tell” 6
Encourage trial and error when proving hypothesis 5
Enjoy the units 3
Through the year, allow the children to take risks 3
Ask questions 8
React 3
Show great enthusiasm 3
<table>
<thead>
<tr>
<th>Initial Selective Themes for Survey Response</th>
<th>Total Number of Codes for Each Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item Nine</td>
<td></td>
</tr>
<tr>
<td>1 - Learning Styles</td>
<td>2</td>
</tr>
<tr>
<td>2 - Assessment</td>
<td>1</td>
</tr>
<tr>
<td>3 - Teacher and his/her personal characteristics</td>
<td>45</td>
</tr>
<tr>
<td>4 - Resources, props and materials</td>
<td>25</td>
</tr>
<tr>
<td>5 - Hands on Opportunities for Learning</td>
<td>32</td>
</tr>
<tr>
<td>6 - Constructivist Learning-Exploration</td>
<td>68</td>
</tr>
<tr>
<td>7 - Relevance to Everyday Life</td>
<td>10</td>
</tr>
<tr>
<td>8 - Questioning Strategies</td>
<td>26</td>
</tr>
<tr>
<td>9 - Collaboration</td>
<td>26</td>
</tr>
<tr>
<td>10 - Engagement</td>
<td>38</td>
</tr>
<tr>
<td>11 - Multidisciplinary</td>
<td>10</td>
</tr>
<tr>
<td>12 - Do not understand</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>263</td>
</tr>
</tbody>
</table>
Survey Item 10: What are some of the challenges you face when you are teaching science?

<table>
<thead>
<tr>
<th>Survey Item 10 Responses</th>
<th>Codes for Survey Item 10 Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not teaching science this year</td>
<td>8</td>
</tr>
<tr>
<td>Materials; buy my own. No resources/textbooks. I often make my own</td>
<td>5</td>
</tr>
<tr>
<td>Teach myself first (no training)</td>
<td>7</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
</tr>
<tr>
<td>Assessment of very young children</td>
<td></td>
</tr>
<tr>
<td>Lack of resources</td>
<td>4</td>
</tr>
<tr>
<td>I don’t know that much about science</td>
<td>6</td>
</tr>
<tr>
<td>I can only really teach straight from the curriculum</td>
<td>5</td>
</tr>
<tr>
<td>Hard to be excited about teaching a unit that doesn’t excite children</td>
<td>5</td>
</tr>
<tr>
<td>Not enough material</td>
<td>4</td>
</tr>
<tr>
<td>Incomplete curriculum resources</td>
<td>5</td>
</tr>
<tr>
<td>Lack of time</td>
<td>1</td>
</tr>
<tr>
<td>Science is not a priority</td>
<td>1</td>
</tr>
<tr>
<td>Difficult presenting abstract concepts</td>
<td>6</td>
</tr>
<tr>
<td>Learning all the content prior to teaching the material</td>
<td>6</td>
</tr>
<tr>
<td>Knowing everything that the kids want you to know</td>
<td>6</td>
</tr>
<tr>
<td>Time to prep materials</td>
<td>1</td>
</tr>
<tr>
<td>Lack of resources</td>
<td>4</td>
</tr>
<tr>
<td>Time for preparation</td>
<td>4</td>
</tr>
<tr>
<td>Time to clean up</td>
<td>1</td>
</tr>
<tr>
<td>Time!</td>
<td>1</td>
</tr>
<tr>
<td>Having to, and wishing to, incorporate language arts skills</td>
<td>8</td>
</tr>
<tr>
<td>If I could, I would teach my entire curriculum through science</td>
<td>8</td>
</tr>
<tr>
<td>Don’t have the background or prior knowledge</td>
<td>6</td>
</tr>
<tr>
<td>Students don’t understand that there is no “right”/ “wrong” strategy/observation/ result</td>
<td>9</td>
</tr>
</tbody>
</table>
If their predicated and outcome don’t “match” they feel disappointed or often think that they’ve done something wrong  
Not enough time. To really get into experiments and activities  
Time- never enough!  
Having a big enough wealth of knowledge to offer the children  
Time to do it  
Materials  
Lack of set district curriculum  
Lack of district resources  
Time! Some of the lessons are fun and exciting and require time to truly understand  
Time constraints  
I don’t love teaching science  
Greatest challenge I face is making sure I am fully engaged in the teaching  
Time to prepare and set up for science experiments  
Availability of age appropriate materials  
Availability of interesting materials  
Time for valuable lessons  
Preparation of materials for hands-on activities  
Time in the curriculum to go in depth into projects  
I don’t always have the background info. On a topic  
This is my first year teaching 3rd grade and I don’t feel I know enough about electricity, astronomy etc.  
It is sometimes hard to explain concepts w/age appropriate language  
Time, time time! Never enough time!  
Days are so fragmented and science truly needs solid blocks  
Time to set up  
There is no time  
Modifying science curriculum
Management for inquiry and based research and only one ME!  6
Time!!!  1
Time is taken during the day for other subjects and activities  1
Difficult to prepare and teach what I want to teach and in the way I know how  8
Some of the units we teach require a lot of materials  4
Set-up. Takes an additional amount of time to do  4
Some gaps in content knowledge, depending on the particular topic  8
Time  1
The terminology can be hard for the little ones  9
Allowing students to come to their own answers and conclusions, [not] leading them[students] to the answers  3
Follow up projects to activities for inquiry  6
[Follow up projects to] units for inquiry  6
Thinking of hands on activities that teach the students the content  6
In Pelham we use Foss kits which I find to be very basic, if not boring  4
No standardization of materials  4
No standardization of materials and curriculum  5
Need more materials  4
Preparation of materials  4
Time – management  1
Background knowledge (but I’m willing to learn)  6
Prep of materials  4
Time management  1
Answering questions I may not know the answers  6
Time  1
Resources  4
Experiments  8
Literature in to math  8
<table>
<thead>
<tr>
<th>Issue</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary development</td>
<td>8</td>
</tr>
<tr>
<td>Materials (need more materials for science)</td>
<td>4</td>
</tr>
<tr>
<td>Children not following proper procedures</td>
<td>2</td>
</tr>
<tr>
<td>Children not completing procedures in sequential order</td>
<td>2</td>
</tr>
<tr>
<td>Frequently have to switch gears to keep them focused</td>
<td>2</td>
</tr>
<tr>
<td>Frequently have to switch gears to engage children at this level</td>
<td>2</td>
</tr>
<tr>
<td>Not enough time</td>
<td>1</td>
</tr>
<tr>
<td>Time constraints</td>
<td>1</td>
</tr>
<tr>
<td>I don’t consider myself to be a “science person”</td>
<td>3</td>
</tr>
<tr>
<td>My knowledge of science is limited</td>
<td>3</td>
</tr>
<tr>
<td>Finding time in a packed day for science</td>
<td>1</td>
</tr>
<tr>
<td>Finding time especially during “test prep” season!</td>
<td>1</td>
</tr>
<tr>
<td>Science not being considered to be important enough in elementary curricula</td>
<td>5</td>
</tr>
<tr>
<td>Challenging to do as much hands on learning as I like</td>
<td>3</td>
</tr>
<tr>
<td>Time it takes to gather materials</td>
<td>1</td>
</tr>
<tr>
<td>Getting appropriate hands-on materials</td>
<td>4</td>
</tr>
<tr>
<td>Many</td>
<td>8</td>
</tr>
<tr>
<td>Managing class with 25 kids</td>
<td>3</td>
</tr>
<tr>
<td>Doing experiments with 25 kids</td>
<td>3</td>
</tr>
<tr>
<td>State assessment gears science to test</td>
<td>2</td>
</tr>
<tr>
<td>State assessment gears science not to explore what kids want</td>
<td>2</td>
</tr>
<tr>
<td>Not an expert</td>
<td>3</td>
</tr>
<tr>
<td>Not strongest subject</td>
<td>3</td>
</tr>
<tr>
<td>Sometimes feels hard but still try my best</td>
<td>3</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
</tr>
<tr>
<td>Materials</td>
<td>4</td>
</tr>
<tr>
<td>Quick lessons with one objective</td>
<td>5</td>
</tr>
<tr>
<td>Easy lessons with one objective</td>
<td>5</td>
</tr>
</tbody>
</table>
Time constraints in the classroom

Not exactly sure what is expected at my grade level

Time to set up "hands on experience" for the children

Time to set up or "little labs" for the children

Engaging materials

Breaking out of my own childhood attitudes about science that it’s boring

$ For supplies

Time within the curriculum

Lack of time

Lack of materials

Often students get science through non-fiction reading

Lack of materials

Lack of time

Finding enough time

Finding enough materials to do a thorough job

I do not have a clear cut list that guides me

I have a curriculum, but I would like something scripted that I could add to

Lack of resources

Lack of time

No materials

No kits[science]

Everything I must buy

Everything I must come up with myself

Lack of materials

Curriculum seems vague

No pre-determined teaching points

Not enough time to infuse all the other subject areas with science

Time is very tight
Not enough time
[time] Even in integrating with other subjects, reading, writing, math
Lack of background knowledge!
Lack of a schedule to best complete the unit using the concepts most important to that unit
Lack of a schedule to best complete the unit using the concepts most important to that unit
Not having the resources or materials needed
Time, time, time
Curriculum changes
Not having a sink in the classroom
Not enough time to prepare materials
Supplies run out quickly
Supplies don’t always cover all that’s needed to be taught
I need to find ways to supplement
Time
Resources
Lack of training
Having enough time
Materials
Finding enough time to fit it in
Finding enough resources
Not enough supplies
Not enough time
Not enough money
Not enough field trips
No time;
No materials
No supplies;
Outdated materials
Having enough supplies 4
Time; 1
Materials 4
Enough time 1
Time; 1
Availability of materials 4
Science kits will need to be replenished 4
[Science kits] the district will not be able to afford it 4
Time; 1
A lot of time is spent on reading 1
A lot of time is spent on math 1
Availability of consumables 5
Time 1
Materials 4
Time 1
Material needed 4
Finding the time 1
Outdated text 4
Getting the materials 4
Finding the time 1
Time 1
So much of the day is allocated for Language Arts and Math 1
Lack of materials 4
Outdated [materials] 4
Time to complete projects 1
Not enough materials 4
Outdated texts 5
Not enough time 1
Only teach science in the fall till Christmas. Then after March, because of test prep CMT.

Lack of materials
Outdated materials
Time to teach the concepts across the school day
Curriculum is not very teacher/user friendly
Have groups of students for only 30 minutes a day which limits the teaching/learning process
Not enough time to integrate
Knowledge of the state [CT] curriculum
[Topic that] overlap with other grades
[Activities that] overlap with other grades
Time
Having the right materials
Not sure myself of the scientific principle behind the experiment
lack of time because of pressure to teach literacy curriculum
Not enough time to do all the experiments I want
trying to fit science into my already busy schedule
Not enough adults in the room
Making sure concepts are explained in appropriate ways
not enough time
materials- making sure they are up to date
Fitting it into a day’s activities: reading, writing, math, social skills, etc.
Set-up
Time
time to go as in depth as I would like to into the science curriculum
Keeping up w/ new information
false information on the internet
every subject area is getting squeezed nowadays, but none perhaps as much as science
giving the students a full and rich science experience in a shorter window of time.
Units 1 and 2 of Science 21 (Boring) 5
Science queezed out by required literacy and math blocks. 1
Lack of $ for field trips 4
Lack of time is huge factor 1
Units are limiting (as presently written) –for engaging students in discussion and deep thinking 5
Time to let children experiment 1
Time to discuss 1
Time to react 1
Time constraints due to other curriculum requirements 1

<table>
<thead>
<tr>
<th>Initial Selective Themes for Survey Response Item Ten</th>
<th>Total Number of Codes for Each Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Lack of Time</td>
<td>81</td>
</tr>
<tr>
<td>2 - Assessment</td>
<td>3</td>
</tr>
<tr>
<td>3 - Teacher and Personal Characteristics</td>
<td>13</td>
</tr>
<tr>
<td>4 - Resources, props, materials, time, curriculum</td>
<td>75</td>
</tr>
<tr>
<td>5 - Lack of Curriculum</td>
<td>32</td>
</tr>
<tr>
<td>6 - Teacher knowledge</td>
<td>20</td>
</tr>
<tr>
<td>7 - Lack of professional development</td>
<td>2</td>
</tr>
<tr>
<td>8 - We can't understand enough to code</td>
<td>10</td>
</tr>
<tr>
<td>9 - Students' understandings of science</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>242</td>
</tr>
</tbody>
</table>
### Survey Item 11: How do you encourage students’ questioning and thinking skills in your classroom?

<table>
<thead>
<tr>
<th>Survey Item 11 Responses</th>
<th>Codes for Survey Item 11 Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>I answer questions with more questions</td>
<td>9</td>
</tr>
<tr>
<td>Analyze data. Ask, “Why do you think that happened?” or “What would happen if we change (a variable)?”</td>
<td>9</td>
</tr>
<tr>
<td>Search for answers in text, too (builds language arts).</td>
<td>3</td>
</tr>
<tr>
<td>Encouraging the children to wonder</td>
<td>1</td>
</tr>
<tr>
<td>Modeling the inquiry model for learning</td>
<td>3</td>
</tr>
<tr>
<td>KWL charts /other visuals that initiate discussion and debate</td>
<td>3</td>
</tr>
<tr>
<td>Asking more thought-provoking questions</td>
<td>9</td>
</tr>
<tr>
<td>K.W.L</td>
<td>3</td>
</tr>
<tr>
<td>Start with an essential question and revisit it often</td>
<td>9</td>
</tr>
<tr>
<td>Give a lot of open-ended questions</td>
<td>10</td>
</tr>
<tr>
<td>Allow for student choice within the content area</td>
<td>7</td>
</tr>
<tr>
<td>When they have questions we brainstorm ways to find answers</td>
<td>11</td>
</tr>
<tr>
<td>Have an “I wonder” center where kids articulate what the wonder about</td>
<td>1</td>
</tr>
<tr>
<td>Students often need a reminder of the question words they can use during science.</td>
<td>9</td>
</tr>
<tr>
<td>Charting vocabulary helps</td>
<td>3</td>
</tr>
<tr>
<td>They write in science journals the questions they have</td>
<td>4</td>
</tr>
<tr>
<td>I always start off each unit of study with, “I wonder…”</td>
<td>1</td>
</tr>
<tr>
<td>“I wonder…” statements;</td>
<td>1</td>
</tr>
<tr>
<td>Time to explore</td>
<td>1</td>
</tr>
<tr>
<td>Encourage children to wonder about everything in every subject</td>
<td></td>
</tr>
<tr>
<td>Explore and discover</td>
<td>5</td>
</tr>
<tr>
<td>No right or wrong answers</td>
<td>7</td>
</tr>
<tr>
<td>Ask open-ended questions</td>
<td>10</td>
</tr>
<tr>
<td>By asking open ended questions and also asking them to elaborate more</td>
<td>10</td>
</tr>
<tr>
<td>Giving them time to think and possibly rethink about their responses</td>
<td>7</td>
</tr>
</tbody>
</table>
Ask the first question ie: Can we use the supplies in the baggies to make the light bulb light? Then challenge them to try it with only 2 of the supplies
Applying the same concept of a circuit in a variety of ways. Inevitably they start “The what ifs…What if I tried to make a circuit with this------ from my desk
Group experiences where they can use manipulatives, books, and the computers to expand their learning
Accept all answers – value them
Give them enough wait time
I set up the environment with a culture and activities that promote questions and the generation of hypotheses.
Through discussion
Socratic seminars
Pair/share
Make them feel comfortable in the classroom
I always welcome questions
Encourage thinking by thinking, questioning and wondering aloud as modeling
Use of essential questions
Students write questions on post-its.
Begin all units by asking the children what they know and what they want to know
Though an inquiry approach
Show students pictures, artifacts, documents, experiments
Let them participate in the lesson rather than teacher directed
I invite them to “think like scientists”
Learn through hands on activities to try to find answers instead of being given answers
Let them design their own skills – what do they want to find out? How will they go about finding out?
Evaluate their work 3
Creative questions 10
Open ended questions 10
Inquiry research 5
Teacher question prompts 10
Interviews 10
Students are allowed to experience inquiry based research 5
[Students] discover information 5
Formulate questions on their own 9
Critical questioning 9
Partnerships 12
Peer work 12
By modeling 3
Letting them know that all questions are valuable and important 7
I post their thinking all over the room in charts 4
By presenting them in situations where they have to use their critical thinking to figure out what to do 5
Giving them research projects that are student directed 5
I use an inquiry – based learning approach. Students ask questions before the unit, and we work to answer them by creating labs 5
Researching, etc. 5
My science curriculum is taught through an inquiry approach to learning. 5
Have science books readily available 3
Teach a lot of science lessons every week 3
Use post it’s for questioning skills 9
We use our journals and write to our plants 4
I try to make it creative 7
I have created a classroom environment where each student is valued 7
[I have created a classroom environment where] students feel comfortable to
ask questions
I do a lot of modeling
Foster environment that welcomes inquiry
[Foster environment that] post children’s questions
[Foster environment that] promote follow-up questions
By encouraging the students to participate in class discussions
Posing questions
A lot of problem solving math activities that have more than one solution.
We share the different ways in which the children figured out the solution to the problem this helps kids develop a variety and strategies to try when confronted with a problem
Look at a problem and think through multiple ways to come up with a solution. This develops their thinking skills and doesn’t limit them to feel there is only one right way to do something
Getting them to target their questions toward developing deeper understanding can be challenging. In my class there are no wrong questions
Don’t supply answers until they have time to play w/materials
And think; They need to hypothesize/guess first
Offer engaging experiences
Engage students in higher level discussion
Take students through scientific method
Probe questions
Provide students w/opportunities to question/predict/infer
Time
Modeling
Encourage questions; it is an ongoing skill I teach and reinforce
Through experimentation
Through Labs
Through Readings

301
Through connection to their lives
Asking higher order questions
Encourage cooperative learning
Have them observe something
Children will then raise questions
I have them come up with their own questions
Relate it to their own experience
Giving open ended questions
Time for discussion
Living and non living things – trees and leaves topics we’ve explored outside
Creating a “safe” environment
Taking results
Making mistakes is ok
Allowing for questions – even if it goes a bit off topic …
Interesting ideas often pop up
Interesting discussions often pop up
Helpful when we can connect it to learning
Living and non living things – trees and leaves topics we’ve explored outside
Students keep a science journal
Students work in groups
Groups [offer] opportunity for conversation
Groups [offer] opportunity sharing of ideas
Going outside whenever possible
We can connect it [going outside] to learning
I am accepting of new ideas
Many ways to look at the world
Making connections to the real world from books
Encouraging curiosity about things kids don’t know
Before answering questions, I ask other students to think about possible responses
Share [possible responses] with the class.
Leave questions unanswered for students to ponder
Model
Allow time for exploration
I model.
We read science articles; I have them list questions
We read passage from text; I have them list questions
Tell them we could look it [questions] up.
I always ask questions.
I get them to do the same
I model thinking!
Science labs were useful to staying on task
Clear explanations what the questions to be answered
Talk was accountable to science questions
Age appropriate
Providing Time of [for] questions based on weather/seasons (planting – harvesting)
Providing Time of [for] discussions based on weather/seasons (planting – harvesting)
Providing Time of [for] questions based on observation (rocks, solids, liquids)
Providing Time of [for] questions based on /classification
Providing Time of [for] discussions based on observation (rocks, solids, liquids)
Providing Time of [for] discussions based on /classification
Having materials for observation in the classroom
Having children bring in interesting things (rocks, plants etc.) for observation
Having children bring in interesting things (rocks, plants etc.) for discussion
Prompt them, ex. “What makes you say that?”  
9
Prompt them, ex. or “How do you know?”  
9
Prompt them “Say more”  
9
I stick to the basis of the Scientific Method  
5
I stick to the basis Blooms Taxonomy  
10
Always ask what they are thinking  
9
Always accept what they are thinking  
7
Open environment with question stems  
9
Safe environment  
7
Model my thinking  
3
Praise students who do independently  
7
Challenging them to push their thoughts by including why  
9
I encourage my students to have conversations about their observations  
12
Then link it [conversations] to writing or other media, such as technology or Art  
8
Periodically researching the answers to their questions together  
12
Always encourage them by asking questions of myself and  
1
Thinking aloud to model for them  
3
Turn and talk discussions  
12
By asking open-ended questions  
10
By allowing students to express their opinions  
12
We try it out  
5
[Teacher's class] Had bugs that we didn’t have in acorns- they required that we researched and some did even more at home and brought them in to share  
5
I ask questions that I do not know the answer to  
10
Together we find the answer  
5
I have an anonymous question box  
7
By encouraging them to question in all content areas  
8
By encouraging them to think in all content areas  
8
By continuing to ask open-ended questions
I let them explore on their own
I let them come up with questions on their own
I let them connections on their own
We review the brainstorming process
I let them know I am more interested in their thoughts than their accuracy
I let them know I am more interested in their efforts than their accuracy
I am positive
Never tell them they’re wrong
I encourage the students to explain how they came to the answer/conclusion they got
All questions are important
Always asking what they are thinking
What do you think will happen if???
Allow them time to explore the topic
Use words like “I wonder” or “I notice”
Impress on our young students that “we are all scientists”, whatever we are learning
Allow all answers to be shared
Explain thought processes
Ask “How”
Ask “Why”
Have them talk to each other
Having them write down any questions they might have
Encourage them to go above the experiment
Real –life examples
Wait-time
Partner discussions
Students turn and talk to each other
Through classroom discussions  12
Modeling  3
Thinking aloud  3
Science journals  4
Asking questions that have no right/wrong answers  10
Modeling  3
Students keep a science journal  4
Students are encouraged to talk  12
Students are encouraged to research  5
Modeling  3
Giving students a science journal  4
Discuss with classroom peers  12
Documenting their thinking; integrating in other subject areas  8
Modeling  3
Encouraging use of the different types of questions in other subjects  8
Integrating same questions across subject areas  8
Integrating science-based questions across the curriculum  8
Give them a chance to explain their thinking  4
Give them a chance to defend their thinking  4
Brain-storm  11
Experiment  5
Share  12
Tap into background knowledge  8
Using a variety of questions from a variety of levels  9
Higher level thinking skills  10
My students are always talking and engaging in conversations. It is the shape of the program  12
By asking open-ended questions through observation  10
Discussion  12
Give them a lot of time for observation 7
We give them science journals 4
Hands-on experiences seem to encourage questioning 5
Hands-on experiences seem to encourage curiosity 1
Keep asking them to explain their thinking 4
Continually asking “why” 1
Reading books 3
Having kids think critically before, during and after (reading books) 3
Setting up opportunities that lend themselves to generating questions 9
I ask children questions 9
Listen to their answers 7
Ask them to explain their thinking 4
By giving them information in different science concepts 3
By giving them experiences in different science concepts 5
Introducing the children to research 5
Partnership work 12
Hands-on learning 5
Group work 12
Encourage inquiry as much as possible 5
Good to have questions, even if we don’t have an opportunity to find the answers 7
By valuing their ideas 7
Teaching students to value (others) ideas 7
Providing as many times as I can, areas where students can question 7
Providing as many times as I can, areas where students can explore 5
Fostering no “bad” questions 7
Classroom being accepting 7
Letting them try to answer the questions 7
Keeping an open dialogue 7
Providing a safe environment to ask questions
Students naturally think of questions when presented with phenomena
Ask a lot of “Why do you think…” type questions after asking “What did you notice?”
Asking “What did you notice?”
Pointing them to the rich collection of non-fiction we have for the book bags
Highlight that in some way so that students desire those books
Kids sharing from trips on weekend experiences with their family
Sharing from museum trip
Share and bring in stuff
Stuff piques the interest of others when they do that
Pose “what if” questions
Encourage predicting
Use student “observations” to emerge them in discussions
Support their reasoning (evidence which they feel is logical and true)
Risk free environment
Inquiry method
Letting them pose questions;
Experiment
Seek answers
Seek answers
Seek answers
<table>
<thead>
<tr>
<th>Initial Selective Themes for Survey Response Item Eleven</th>
<th>Total Number of Codes for Each Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encouraging Wonder - 1</td>
<td>29</td>
</tr>
<tr>
<td>Content-based Strategies - 3</td>
<td>38</td>
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<tr>
<td>Metacognitive Strategies - 4</td>
<td>15</td>
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<tr>
<td>Inquiry-based Strategies-5</td>
<td>36</td>
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<tr>
<td>Positive Classroom Environment - 7</td>
<td>64</td>
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<tr>
<td>Making Learning Relevant - 8</td>
<td>13</td>
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<tr>
<td>Developing Student Questions - 9</td>
<td>32</td>
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<tr>
<td>Using Open-ended/Creative/Higher Order Questions - 10</td>
<td>18</td>
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<tr>
<td>Using Brainstorming - 11</td>
<td>3</td>
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<tr>
<td>Promoting Discussion and Interaction with Others - 12</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>277</td>
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</table>