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THE DEVELOPMENT AND VALIDATION OF AN INSTRUMENT TO MEASURE PRESERVICE TEACHERS' SELF-EFFICACY IN REGARD TO THE TEACHING OF SCIENCE AS INQUIRY

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Abstract

The purpose of this study was to develop, validate and establish the reliability of an instrument that measures preservice teachers' self-efficacy in regard to the teaching of science as inquiry. The instrument (TSI) is based upon the work of Bandura, Riggs, and Enochs & Riggs (1990). The study used Bandura's theoretical framework in that the instrument uses the self-efficacy construct to explore the beliefs of prospective elementary science teachers with regards to the teaching of science through inquiry: specifically, the two dimensions of self-efficacy beliefs defined by Bandura: personal self-efficacy and outcome expectancy. Self-efficacy in regard to the teaching of science as inquiry was measured through the use of a 69-item Likert scale instrument designed by the author of the study. A 13-step plan was designed and followed in the process of developing the instrument.

To develop the instrument, the researcher first defined the construct to be measured, self-efficacy, as well as a content matrix to represent the five essential elements of classroom inquiry. Second, eighty-one draft Likert type items for the instrument were prepared with at least three representations of each cell in the Essential Elements of Classroom Inquiry matrix. These draft items were modeled after those composing the STEBI A and STEBI B (Riggs, 1988; Enochs & Riggs 1990). This version of the TSI instrument was given to a panel of reviewers that consisted of experts within the field of science education and self-efficacy research. Feedback from the panel was then used to revise Version 1 of the instrument.

Following this revision, a ninety-four item instrument was drafted. This version, Version 2, was also reviewed by the panel of experts. Feedback from the reviewers was

collected by the researcher and then analyzed. This same process of content and construct validity was conducted through eight versions of the TSI to ensure clarity and comprehension.

Version 7 of the instrument was administered to the approximately 200 prospective elementary teachers in the Elementary-Kindergarten Education Program (EK ED) at The Pennsylvania State University in the beginning of the Fall semester of 2003. The participants were enrolled in six sections of SCIED 458: Teaching of Science in the Elementary School. This group of participants represented the intended population for the final instrument. Item analysis was performed with the following goal:

> What is the most reliable and valid combination of items to compose the TSI for the purposes of assessing preservice elementary teachers' self-efficacy in regard to the teaching of science through inquiry, and the two dimensions of self-efficacy: personal self-efficacy and outcome expectancy?

The data obtained from administering Version 7 of the instrument to the SCIED 458 classes was then used to develop Version 8. Version 8 was also administered to the same group of preservice elementary teachers during the week of December 1, 2003. Although the actual content of the first draft was not changed as a result of data analysis, aesthetic revisions were made to enhance the ease with which a participant completed the instrument.

Using the results from Chronbach Alpha and Analysis of Variance, a 69- item instrument was found to achieve the greatest balance across the construct validity, reliability and item balance with the Essential Elements of Classroom Inquiry content

matrix. Based on the standardized development processes used and the associated evidence, the TSI appears to be a content and construct valid instrument, with high internal reliability for use with prospective elementary teachers to assess self-efficacy beliefs in regard to the teaching of science as inquiry. Further study of the instruments construct validity is recommended. Norming the TSI may provide some insights and will provide additional information on the TSI that will be useful to users. Additionally, development of a form of the TSI for practicing elementary teachers should be pursued.

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Chapter 1

Introduction and Rationale

Reform of science education in the United States is a difficult, multifaceted task. Within the realm of science education reform, emphasis relies heavily on the importance of scientific inquiry experiences for K-12 learners. *The National Science Education Standards* (NSES) (National Research Council, 1996) is a current reform document aimed at improving scientific literacy for all. In order to achieve this challenging goal, the standards emphasize an approach to teaching and learning about science, which emphasizes scientific inquiry as a prominent feature. However, many teachers report that they have never experienced teaching or learning science as inquiry. This is particularly true at the elementary level. Thus, teacher preparation experiences have become a logical target for change.

Before describing the nature of this study, it would be advantageous to first define the term "inquiry" that will be used frequently throughout this study. Inquiry can take on a multitude of meanings depending on the audience. Because teaching science as inquiry is such a complex, multifaceted task, there are many definitions available in the current literature pertaining to science that attempt to capture the components of this practice.

Although definitions may vary, the importance of teaching school science as inquiry is not a new idea. In fact, Joseph Schwab (1962) addressed the idea of "enquiry" noting that "Enquiry operates through miscarriage and tends toward frustration. It does not itself have a guide or a set method for which to follow. It is engaged in invention, hence failures are among its normal expectation" (p.17). Schwab explains the following processes that occur when one is engaged in enquiry: "Knowledge of the subject unfolds.

Experimental techniques are refined and invented. The new knowledge lets us envisage new, more adequate, more telling conceptions of the subject matter. The growth of technique permits us to put the new conceptions into practice as guiding principles of a renewed enquiry" (p.14).

Similarly, the National Science Education Standards (NRC, 1996) describes inquiry as "…a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results" (p.23). Although inquiry can be attributed to the aforementioned features, it cannot be defined by a specific and well-defined set of characteristics or skills (National Research Council, 2000). Specifically defining what teaching science as inquiry is, and how it should be implemented in the classroom is an extremely difficult task.

In December 1995, the National Research Council (NRC) released the National Science Education Standards (NSES), which indicate "a vision of science education that will make scientific literacy for all a reality in the 21st century." A prominent feature of the NSES is a focus on scientific inquiry (National Research Council, 2000). The National Committee on Science Education Standards and Assessment (1996) has asserted that students should "engage in aspects of inquiry as they learn the scientific way of knowing the natural world, but they should also develop the capacity to conduct complete inquiries" (p. 23).

In 1996, the National Research Council released the *National Science Education Standards* (NSES). An interesting aspect about the NSES is the way in which the term inquiry is defined. Inquiry is described in two ways. First, the NSES discusses scientific inquiry as the processes scientists engage in to explore natural phenomena. Scientists engage in inquiry to form explanations based on the evidence collected as a result of these explorations.

Inquiry is also described in relation to students' science learning. For this description, the NSES refers to content. This describes the activities of which students engage in to develop knowledge and understanding of scientific ideas. In addition, these activities lead to the acquisition of *abilities* to do inquiry and *understandings* about inquiry.

Inquiry is also referred to as an approach to teaching science. While teachers should utilize an arsenal of different strategies when teaching science, the NSES describes five essential features of classroom inquiry that apply across all grade levels (Table 1.1).

Table 1.1. Essential Features of Classroom Inquiry and Their Variations

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

Source: National Research Council, 2000, p.29

In particular, these essential features distinguish between how inquiry is practiced by scientists and inquiry as a means for teaching and learning science. These essential features introduce important aspects of science to students while simultaneously assisting them in developing knowledge in regard to specific science concepts. Within each of the five essential features of classroom inquiry, there are variations that can be labeled as variations within a continuum of inquiry experiences. To determine whether an experience is full or partial, one must refer to the amount of student and teacher involvement. Partial inquiries have greater teacher involvement and less student involvement whereas full inquiries have greater student involvement, and less teacher involvement. Table 1.1 is an illustration from Inquiry and the National Science Education Standards (National Research Council, 2000) that indicates the different variations of classroom inquiry.

Although scientific inquiry may be difficult to define, the National Science Education Standards discuss inquiry teaching practices which include: a) guiding students in developing their own questions to examine, b) providing meaningful concrete experiences from which such questions can be generated, c) facilitating open-ended long-term student investigations, and d) fostering a community of learners who work cooperatively in their investigations (National Research Council, 1996, p.33).

Teaching science as inquiry can also encompass many forms. To distinguish among these various forms of inquiry, science education researchers have developed an inquiry ‘continua,’ based upon the degree of independence students have in asking and answering questions (Schwab, 1962; Windschitl, 2002). At one end of the scientific inquiry continuum are confirmation experiences, in which students verify known scientific principles by following a given procedure. The next type is referred to as structured inquiry and involves the presentation of a question from the teacher. However, the students do not know the answer to this question. The students are then given a procedure to follow in order to complete the inquiry. In guided inquiry, students are provided with a problem to investigate, however the methods for addressing this problem are left to the students. Finally, at the opposite end of the continuum are open or independent inquiry experiences. During these experiences, teachers allow students to develop their own question and design their own investigations (Windschitl, 2002).

Given the nature of teaching and learning science as inquiry, it is important to point out that this type of learning and/or teaching is not a neat and tidy process. The National Research Council describes a more specific set of variations to encompass inquiry learning (2000). The NRC proposes a definition that "…distinguishes inquiry-based teaching and learning from inquiry in a general sense and from inquiry as practiced by scientists" (p.24). At the center of this definition are the five essential features of classroom inquiry.

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

These features draw attention to students engaging in scientifically oriented questions and giving priority to evidence when formulating explanations. In addition, students evaluate their explanations in light of alternative explanations and then communicate their proposed explanations to others.

It is important to note that just as there is no one correct way to teach science, there is no one way to incorporate inquiry into the science classroom. These standards provide a framework for teaching science as inquiry and they themselves encompass several variations. Each of these variations will differ based on the amount of student involvement as well as the amount of teacher involvement. For example, when students are engaging in scientifically oriented questions, the amount of inquiry will vary depending on the origin of the question. If the question was presented by the teacher the amount of inquiry will be less than if the students developed their own questions to investigate. In essence, within any classroom a lesson may be more or less student directed depending on the features implemented.

Clearly, scientific inquiry can be defined and described in a number of ways; however, for the purposes of this research, I will be using the definitions set forth by the National Research Council (2000). My definition for the purposes of this research draws upon the essential features of classroom inquiry as the essence of inquiry, particularly the notion of giving priority to evidence and explanation.

The Importance of Scientific Inquiry Experiences

Given the current trends in contemporary science education reform, science as inquiry is considered to be an important part of the restructuring. A rich learning environment, with a focus on inquiry-based learning creates opportunities for children to internalize or transform new information, which in turn allows students to create and expand their individual cognitive structures (Lee & Krapfl, 2002). This type of learning fosters conceptual understanding rather than rote learning of science concepts and facts (Lee & Krapfl, 2002). Children should know how to pursue their own questions about the world around them. This however, does not happen naturally in the classroom, and students will need to have support in their pursuits of understanding phenomena. When science is taught through the process of inquiry, children will be able pose questions and seek answers based on observation and exploration. The evidence gathered throughout this process can then be used by the students to answer their own questions, as well as future questions that may arise. Inquiry allows student the opportunity to explore and simultaneously requires them to learn something about how science is done (National Research Council, 2000; Drayton & Falk, 2001).

The foundation of scientific inquiry rests in scientific knowledge as “fragile, dubitable, and subject to change” (Schwab, 1962, p.14). When engaged in the process of inquiry, students are learning science and they are also learning about science. When science is more authentic, students are simultaneously learning the science concepts, the processes of investigation, as well as how science is done.

To address the idea of scientific inquiry, both the roles of the teacher and the students will indeed change. “The teachers and students become cooperative and communicative pursuers of common problems” (Schwab, 1962, p.71). The students must relinquish the “habits of passivity, docile learning, and dependence on teachers and textbooks, in favor of an active learning in which lecture and textbook are challenged. These materials no longer exist as an authoritative form of knowledge but instead exist to become materials to be dissected, and analyzed” (p.66). The questions asked within an enquiring science classroom are designed to exemplify to the students the types of questions he/she must ask of the material being explored rather than to discover whether the student knows the correct answer (1962). The teacher must know what questions to ask, when to ask them, when to allow students more time to explore, and where to find the solutions to problems. Through this complex process, "students must learn that there is room for alternative interpretations of data; that many questions have no 'right' answer but only most probable answers or more and less defensible answers; that the aim of criticism and defense of alternative answer is not to 'win the argument' but to find the most defensible solution to the problem" (p.70).

This inquiry approach to teaching and learning science allows the teacher to become more facilitative in nature and the students to become more self-directed. As a result of this shift from a more teacher-centered classroom to a more student-centered classroom, students are able to establish long-term conceptual understandings of science (Kleine, Brown, & Harte, 2002). As noted in theoretical claims supported by empirical evidence, "…greater emphasis on inquiry-based teaching is associated with higher science achievement" (Von Secker, 2002, p. 156). Scientific inquiry introduces students to the content of science, as well as the processes of investigation. It provides the logical framework that enables students to understand scientific innovation (Drayton and Falk, 2001).

Science is all around us, and children have many worthwhile questions that can be answered within the context of school science when they are given the opportunity to seek answers based on observations and experiments. Requiring students to defend their newly acquired knowledge during large and small group discussion is a powerful learning experience for children. Classroom discussions that enable students to apply and synthesize their knowledge in an effort to support their findings enhance their own understandings as well as the understandings of other class members. Although initially, some children may struggle with providing reasons instead of answers, this shift in learning will begin to enhance science understanding (Kleine, Brown, & Harte, 2002). Providing opportunities for students to construct personal and social meaning of the subject matter heightens this understanding. There is substantial empirical and theoretical evidence to support the assertion that inquiry-based science instruction is a starting point for personal construction of meaning and can also lead to higher achievement of all students (Anderson, 1997; Freedman, 1997; Von Secker & Lissitz, 1999).

Although the push for science as inquiry within elementary classrooms is enormous, unfortunately it has not yet become a consistent feature of science classroom practice (Wells, 1995). One possible reason for the lack of inquiry teaching in the elementary science classroom could be a reflection of the mismatch between teacher beliefs and the context of science. The problem with the current teaching of science is that it fails to reflect the changes in science that have occurred over the years. The process of science and the teaching of science have drifted apart. Despite the fact that many classrooms today give the illusion that inquiry is provided, the reality is that inquiry is not authentically and effectively being implemented within science classrooms. Typical lessons involve structured procedures and the results that are actually provided through the textbook, as well as the classroom (Schwab, 1962). The reasoning behind this lack of visibility lies heavily on the conceptions of teachers. Many teachers believe that teaching science as inquiry is very difficult and cumbersome to implement, as well as manage within classroom practice. They also feel that teaching science as inquiry is possible only with above average students and therefore do not attempt to integrate inquiry into their regular education classrooms (Windschitl, 2002).

Although some of these reasons for the lack of science as inquiry experience for elementary children may be viable, teachers themselves need to feel confident utilizing inquiry both as a learner, as well as a teacher so students can learn to participate in the processes of science, develop meaningful understandings of what science is and how it is done, and simultaneously learn science concepts. The NRC (1996) asserts that:

> Students in all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about the relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. (p.105)

Self-Efficacy and Teaching Elementary Science

One way to explain why some teachers choose to eliminate science instruction from their daily routine is through social learning theory. Bandura's social learning theory suggests that people develop a generalized expectancy concerning action-outcome contingencies based upon life experiences (Bandura, 1977). The strength of peoples' convictions in their own effectiveness is likely to affect whether they will attempt to cope with given situations hence, perceived self-efficacy influences choice of behavior settings (Bandura, 1977). When individuals judge themselves as capable of handling situations that would otherwise be intimidating, they become involved in activities and behave assuredly however when situations exceed one's own coping skills, individuals tend to fear and avoid these difficult situations.

The focus of this research on beliefs is a result of the relationship between attitude and subsequent behavior (Bandura, 1986). Bandura's theory of social learning describes two dimensions of efficacy beliefs (personal self-efficacy and outcome expectancy) upon which behavior is based. As explained by social learning theory, people will participate in situations within their self-perceived capabilities, but they will avoid situations within their environment that they perceive to exceed their abilities (Bandura, 1977).

It has been found that efficacy expectations are presumed to influence levels of performance. Research also has indicated the predictive power of one's sense of self-efficacy on subsequent performance. "Efficacy expectations are a major determinant of peoples choice of activities, how much effort they will expend, and of how long they will sustain effort in dealing with stressful situations" (Bandura, 1977, p.194). People give up for different reasons. Individuals will give up trying due to their lack of a sense of efficacy in achieving the desired behavior, or they can possibly give up although they are assured of their capabilities, because they expect their behavior to have no impact on the environment (1977).

Developing self-confidence as a teacher of science is crucial, especially for preservice elementary teachers. In a national survey, Weiss (1978) indicated that elementary teachers teach science an average of 17 minutes per day as opposed to about 90 minutes per day for reading. Several reasons are given to explain this phenomenon, including lack of a strong background in science content; inadequate facilities and equipment; the congested curriculum; poor instructional leadership; and teacher attitude (as cited in Enochs and Riggs, 1990). Although elementary teachers are responsible for teaching all content areas, it is often noted that many elementary teachers do not feel comfortable teaching science (Martin, 2000). The difference between teachers that allow for more science instruction within their elementary classrooms and those who do not may be related to their self-confidence. Those teachers who do not believe in their ability to teach science (low self-efficacy) may avoid science instruction whenever possible (Enochs et al., 1995). Because of the relationship between beliefs, attitudes and behavior with regard to elementary science teaching, this notion supports the conclusion that efficacy beliefs are potentially powerful variables that can influence the amount of science instruction time, as well as the achievement of students in science, at the elementary level.

If science reform is going to be successful and our elementary children are to be provided with effective science instruction, preservice teachers must first be provided with opportunities to experience success as learners of science in reform-oriented contexts (Enochs and Riggs, 1988; Enochs and Riggs, 1990). They themselves must experience first-hand how learning science as inquiry takes place within an elementary school setting. Based on the idea of Bandura's social learning theory (1977), if preservice teachers can experience success within a science methods course, they may then model effective instruction within their own elementary classroom, which in turn may promote the success of their elementary students in regards to the area of science.

Enochs and Riggs (1988) were the first to apply self-efficacy to science teaching through the use of the Science Teaching Efficacy Belief Instrument (STEBI). They define science teaching efficacy as a "…teacher's belief that he or she has the ability to teach science effectively and to affect student achievement" (Riggs, 1988, p.19). Science teaching efficacy belief has two dimensions: personal science teaching efficacy (PSTE), which refers to a teacher's belief in his/her ability to perform science teaching behaviors; and science teaching outcome expectancy (STOE), which reflects a teacher's belief that "students can learn science given external factors such as their family background, socioeconomic status, or school conditions" (Riggs, 1988, p.20).

Although the Science Teaching Efficacy Belief Instrument for Prospective Teachers (STEBI-B) has been determined to be a valid and reliable instrument used to investigate preservice elementary science teachers' self-efficacy, it does not measure teaching efficacy in regards to teaching science as inquiry. For example the following statements, "I understand science concepts well enough to be effective in teaching elementary science," and "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" (Riggs and Enochs, 1990, p.635) seem like effective statements for measuring science teaching; however, they do not capture the essence of scientific inquiry. Although this measure was a reflection of how science was taught during this time period, it does not capture the essential features of classroom inquiry. This measure was developed before reform documents were published therefore it is not a reflection of contemporary educational reform.

In addition the statements, "I find it difficult to explain to students why science experiment work," and "I am typically able to answer students' science questions," again do not support the process of scientific inquiry. These statements infer that the teacher must explain to students the many phenomena that exist in the world of science and that every experiment has a certain procedure that must be followed in order to arrive at the correct answer. These statements do not draw attention to students engaging in scientifically oriented questions and giving priority to evidence when formulating explanations. In addition, the statements do not involve students in evaluating their explanations in light of alternative explanations and then communicating their proposed explanations to others.

These, as well as many other statements included on the STEBI, support the idea that "…the teaching of science today emphasizes the desirability of patience, accuracy, and precision. It testifies to the soundness of existing knowledge, but rarely invites students to discover the limitations of present knowledge or identify unsolved problems and areas of present ignorance. In addition, science education rarely requires students to invent, to devise and explore possibilities alternative to current formulations" (Schwab, 1962, p.39). Although the STEBI was a useful tool in its time, the current standards associated with contemporary science education reform require a new version of this instrument to fit the ever-changing complexities of science education.

Because Bandura (1981) describes self-efficacy as a situation-specific construct, I have chosen to create an instrument that measures self-efficacy in regards to teaching science as inquiry. Teacher efficacy beliefs appear to be dependent upon the specific teaching situations (Riggs and Enochs, 1990). Although there are many instruments used to measure teacher self-efficacy in general terms, specificity is necessary within this study. Due to the fact that elementary teachers typically teach all subjects, and may not feel equally effective at teaching all of them, a subject specific instrument is more informative for the purposes of this study.

As a result of the relationship between beliefs, attitudes and behavior, the purpose of this study is to create an instrument that measures preservice teachers self-efficacy in regards to teaching science as inquiry. As a result of the current trends in science education, and the renewed interest in inquiry, there is a need to focus on the teaching of science as inquiry. Due to the shift in science education, it is my goal to contribute to the science education literature by addressing the ideas of where self-efficacy and inquiry science teaching connect.

As noted earlier, Bandura (1977) asserts that the most complete prediction of human behavior can be derived from knowledge of both self-efficacy and outcome expectancy variables. Personal self-efficacy is a judgment of one's ability to organize and execute given types of performances, whereas an outcome expectation is a judgment of the likely consequence such performances will produce" (Bandura, 1997, p.21). These principles underlie the development of the instrument in this study. The instrument to be created will be based around contemporary ideas about inquiry, as well as grounded in the fundamental ideas of Bandura, (1977) particularly the notion of self-efficacy being a context specific construct.

Contributions

This study will contribute to the literature base available on inquiry science teaching. It will clearly define scientific inquiry, as well as what that may mean to elementary science education. This study will discuss the relationship between self-efficacy beliefs and science teaching. In addition it will contribute to science education through the development of an instrument to measure preservice teachers self-efficacy in relation to the teaching of science as inquiry (TSI).

Research Focus

The purpose of this study is to develop an instrument to measure preservice teacher self-efficacy in regards to the teaching of science as inquiry (TSI).

Definition of Terms

TSI—The instrument developed and validated in this study to measure prospective elementary teachers' self-efficacy beliefs in regard to the teaching of science as inquiry.

Content Validity – degree to which the sample of test items represents the content that the test is designed to measure" (Borg & Gall, 1989, p. 258)

Elementary Science Education – the science teaching and learning that takes place in grades K-6 or in grades K-8 if seventh and eighth grades are located in an elementary school building.

Outcome Expectancy—a persons' judgment of the likely consequences of one's own actions will produce (Bandura, 1997, p.21).

Personal Science Teaching Efficacy Beliefs – "This dimension of elementary science teachers' self-efficacy refers to the teachers' belief in their ability to perform teaching behaviors in science" (Riggs, 1988, p.20).

Personal Self-Efficacy – People's judgment of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1997, p.21)

Science Teaching Efficacy - "…teacher's belief that he or she has the ability to teach science effectively and to affect student achievement" (Riggs, 1988, p.19).

STEBI (Science Teaching Efficacy Belief Instrument) – the instrument developed and validated by Riggs (1988) to measure elementary teachers' personal science teaching efficacy beliefs and science teaching outcome expectancy.

STEBI-B (Science Teaching Efficacy Belief Instrument for Prospective Teachers) – the instrument developed and validated by Enochs and Riggs (1990) to measure prospective elementary teachers' personal science teaching efficacy beliefs and science teaching outcome expectancy.

Reliability –refers to "the degree to which test scores are free from errors of measurement" (Standard for Educational and Psychological Testing, 1985, p.9).

Validity – "the methodological and/or conceptual soundness of research" (Grazioano and Raulin, 2000, p.436). "The appropriateness, meaningfulness, and usefulness of the specific inferences made from test scores. Test validation is the process of accumulating evidence to support such inferences" (The Standards for Educational and Psychological Testing, 1985, p.9).

Chapter 2

Review of Literature

As mentioned in Chapter one, with the publication of the National Science Education Standards, NSES (National Research Council, 1996) the push for inquiry in the science classroom has been revitalized. The NSES assert that science is an active process in which "inquiry is central to science learning" (p.2). Inquiry from this perspective is defined in two different ways. Inquiry is seen as both a learning goal and as a teaching method. First, inquiry is seen as a learning goal through content. These content standards outline the *abilities* students should develop in order to do scientific inquiry, and the *understandings* about scientific inquiry. Second, inquiry is seen as a strategy for teaching and learning science. When these strategies are implemented, students are then presented with opportunities to master scientific concepts (1996; 2000).

When describing what students should know and be able to do, the NSES expectations become more detailed and complex with each grade level. These standards extend beyond a process approach to science, which typically include tasks such as observation, inference and experimentation. The NSES inquiry abilities require students to use scientific reasoning and critical thinking to develop their understandings (National Research Council, 2000). It emphasizes the exploration of students' ideas and curiosities through concrete experiences in an attempt to create new and deepened understandings of science concepts. More specifically, students at all grade levels are required to ask questions, design and conduct investigations, use appropriate tools to gather, analyze and interpret data, construct reasonable explanations based on data, and then communicate these explanations to others. These abilities are very similar from one grade level to another; however, they do become more complex as the grade levels increase to match the cognitive abilities of the learners.

To develop the *understandings* about the nature of scientific inquiry, the NSES cite similar activities, which parallel the standards indicated for the abilities of scientific inquiry. Although this is the case, the understandings of scientific inquiry capture the "how" and "why" aspects concerning scientific knowledge, and the reasons this knowledge changes in response to newly discovered "…evidence, logical analysis, and modified explanations debated within a community of scientists" (National Research Council, 2000, p.21). As a result of these standards, students realize that scientific investigations involve asking and answering questions, developing explanations using evidence, making the results of their investigations public and comparing the answer with what scientists already know (2000). Similar to the abilities of inquiry, the understandings are very similar from one grade to the next; however, they do increase in complexity. As a result of these standards, students begin to understand how and why scientific knowledge develops and changes.

Although inquiry is not the only strategy for teaching science, it is a central part of the teaching standards (National Research Council, 1996; 2000). The NSES provides a comprehensive view of science teaching to describe teaching through inquiry as well as when and how it should be done. The NRC proposes a definition that "…distinguishes inquiry-based teaching and learning from inquiry in a general sense and from inquiry as practiced by scientists" (p.24). Overall the teaching standards are quite broad; however, they do address inquiry strategies for science classrooms. At the center of these standards are the five essential features of classroom inquiry (Please refer to Table 1.1). These features draw attention to students engaging in scientifically oriented questions and giving priority to evidence when formulating explanations. In addition, students evaluate their explanations in light of alternative explanations and then communicate their proposed explanations to others.

It is important to note that just as there is no one correct way to teach science, there is no one way to incorporate inquiry into the science classroom. These standards provide a framework for teaching science as inquiry and they themselves encompass several variations. Each of these variations will differ based on the amount of student involvement as well as the amount of teacher involvement. For example, when students are engaging in scientifically oriented questions, the amount of inquiry will vary depending on the origin of the question. If the question was presented by the teacher, the amount of inquiry will be less than if the students developed their own questions to investigate.

Teaching Science as Inquiry in the Elementary Classroom

Teaching science as inquiry in the elementary classroom is unfortunately, quite rare. In 1977, The National Science Foundation conducted the National Survey of Science Mathematics and Social Studies. The goal for this project was to investigate the following questions using a national probability sample of districts, schools and teachers:

1. What science courses are currently offered in schools?
2. What local and state guidelines exist for the specification of minimal science experiences for students?
3. What texts, laboratory manuals, curriculum kits, modules, etc., are being used in science classrooms?

4. What share of the market is held by specific textbooks at the various grade levels and subject areas?
5. What regional patterns of curriculum usage are evident? What patterns exist with respect to urban, suburban, rural, and other geographic variables?
6. What “hands-on” materials, such as laboratory or activity centered materials, are being used? What is the extent and frequency of their use by grade level and subject matter?
7. What audio-visual materials (films, filmstrips/loops, models) are used? What is the extent, frequency and nature of their use by grade level and subject area?
8. By grade level, how much time (in comparison with other subjects) is spent on teaching science?
9. What is the role of the science teacher in working with students? How has this role changed in the past 15 years? What commonalities exist in the teaching styles/strategies/practices of science teachers throughout the United States?
10. What are the roles of science supervisory specialists at the local district and state levels? How are they selected? What are their qualifications?
11. How have science teachers throughout the United States been influenced in their use of materials by federally-supported in-service training efforts in science? (Weiss, 1978, p.1)

In particular, the results reported for Question 8: "By grade level, how much time (in comparison with other subjects) is spent on teaching science?" were exceptionally telling of the presence of science in the elementary classroom. Weiss (1978), noted that elementary teachers spent an average of 90 minutes a day teaching reading compared to only 17 minutes a day for teaching science. Although these results are shocking, Stefanich and Kelsey (1989) conducted a research project, and they, too, uncovered a similar pattern in relation to the teaching of science. Stefanich and Kelsey (1989) found that in elementary schools, less time was spent on science instruction than on any other major subject area. In a more recent study, McDevitt et al. (1993), indicated that children in the United States were not receiving adequate science or mathematics instruction at both the elementary and high school levels. McDevitt et al. cite many possible contributors to this fact, however, his focus lies with the poor preparation of teachers. McDevitt et al. attempt to make a case for providing students with a model science program to enhance both content knowledge as well as attitudes toward science. The program evolved out of a collaborative effort to improve the preparation of elementary teachers in science. The focus of the model was to "…build integrated knowledge in mathematics and science, develop effective teaching skill, and cultivate self-confidence and positive attitudes toward these subjects (p.596). Instructors delivered the material in ways that modeled effective instruction that would be appropriate for elementary classrooms. Laboratory work, as well as cooperative learning were also woven into the curriculum to provide opportunities for preservice teachers to experience various instructional strategies. The key feature of the project, however, was the participation of an experienced elementary teacher. This teacher was fully involved in all phases of the development, implementation and revision stages of the project.

Results from McDevitt et al. (1993) indicate that participation in the project enhances students' knowledge regarding mathematics and science. Particularly, students developed sophisticated understandings of the relationships between science and mathematics. Attitudes toward teaching science and mathematics were also influenced as a result of participation. Specifically, findings suggest that project students became committed to teaching that encouraged both boys and girls to learn and pursue science and mathematics. In addition, the program was said to "…cultivate concerns about fairness and equity in students' beliefs about exemplary teaching" in science and mathematics" (p.606). Additionally, project students became "far" more eager to teach science and mathematic than did the control group (p.608). They also became more concerned about sharing their thoughts and insights with their colleagues and extending the strategies that they learned as a result of participation. This study supports the notion that if preservice teachers are provided with opportunities to experience reform oriented science in a positive light, they are more likely to enter the elementary classroom and employ similar experiences for their students.

Based on Bandura's (1977) idea of social learning theory, these findings are not surprising. Studies by Hone (1970) and Cunningham and Blankenship (1979) further support Bandura's theory in that they reveal that teachers tend to perform tasks they feel competent in performing, and avoid tasks that present a feeling of inadequacy (as cited in Schoon & Boon, 1998). Furthermore, in a study conducted by Feistritzer and Boyer (1983), it was revealed that many elementary teachers dislike and do not understand science. The gravest concern with these findings was in the implication that these negative attitudes of teachers can be passed on to the children in their classrooms. Given the research that supports the assertion that teachers often omit science from their teaching repertoire, teacher educators should understand and be able to address the possible implications for why this may be occurring.

Contributing Factors to the Omission of Science in the Elementary Classroom

Although the current perspective of science as inquiry is firmly established, it has yet to become a consistent feature of science classrooms for numerous reasons (Wells, 1995). Literature suggests that many barriers to teaching science as inquiry exist. One reason for the lack of inquiry instruction is poor preparation of teachers. This poor preparation further translates into teachers feeling unprepared to teach science. Empirical research reflects this concern noting that inadequate science background is one contributing factor. Feistritzer and Boyer (1983) noted that elementary teachers' science content knowledge was at "an undesirable, seriously low level" (p. 24). Moreover, Dobey and Schafer (1984) found that many elementary teachers were reluctant to teach science due to the fact that they felt that they had little knowledge of science content and science processes.

Through this mixed-methods research with elementary prospective teachers enrolled in a science methods course, Dobey and Schafer (1984) investigated the relationship between elementary teachers' scientific knowledge and their inquiry teaching competency. Results from this study indicate that teachers with minimal science background did not utilized inquiry teaching strategies. These teachers "…allowed fewer student ideas to be investigated and exerted more direct control over the activities than did teachers with an intermediate level of knowledge" (p.48). This exertion of control may have been a way for the teachers to keep children within the confines of their limited knowledge. Furthermore, these teachers with minimal science background reflected a lack of confidence in their teaching.

On the other hand, teachers with superior knowledge did not exhibit more inquiry teaching behaviors as compared to their minimal science knowledge counterparts. Dobey and Schafer (1984) suggest that a possible reason for this finding is connected to the use of instructional time. Teachers with superior knowledge tended to use instructional time to provide children with verbal explanations rather than allowing the students to formulate their own explanations based on evidence. This time spent explaining scientific phenomena detracted from the time that could have been spent with children investigating scientific phenomena in an attempt to formulate explanations. Although teachers with superior knowledge did not use instructional time for implementing inquiry methods, they did however feel more confident and self-assured in their teaching (1984).

Teachers within this study exhibiting intermediate knowledge, tended to have the ideal balance of self-confidence and inquiry teaching methods. These teachers were confident and did not have the tendency to control student's inquiry activity (Dobey & Schafer, 1984). They did not feel threatened by the students' questions; they provided opportunities for the children to investigate their queries. Additionally, these teachers did not suppress inquiry activity in an attempt to make explanations pertaining to scientific phenomena like their superior knowledgeable counterparts. Overall, teachers with intermediate levels of knowledge demonstrated attributes and behaviors conducive to inquiry learning (1984).

Although this research supports the idea that teachers must be scientifically knowledgeable in order to facilitate the necessary experiences to produce concept attainment, it is also possible that teachers with adequate science knowledge tend to stress concepts and facts as opposed to the process of inquiry and discovery (Dobey & Schafer, 1984). For example, Dobey and Schafer found that teachers with superior scientific knowledge tended to avoid inquiry instruction. This notion was attributed to the teachers desire to use instructional time as a means for providing explanations to students, rather than an opportunity for investigating questions through investigation.

In further research similar findings are presented. Anderson and Roth (1989) found that inadequate training in science influences teachers to rely more heavily on lecture and memorization when teaching rather than employing a student-centered approach with a focus on conceptual understanding (as cited in Schoon & Boone, 1998). This assertion supports the claims made by Dobey & Schafer (1984) in that the lack of scientific knowledge on the part of the teacher can inhibit their comfort level pertaining to the use of inquiry methods. Allowing students to investigate their own questions can be seen as a threat due to the fact that the teacher themselves, may not even be sure of the answer to the question. Clement (1982) suggests that most preservice teachers begin their teacher preparation programs lacking basic knowledge within the domain of science. This lack of knowledge often translates into a lack of understanding associated with the relationships between and among science topics (as cited in Zembal-Saul et. al., 2000).

Another important influence on the lack of inquiry experiences within elementary classrooms is related to teachers' alternative conceptions related to the nature inquiry. Many teachers believe that teaching science as inquiry is a very difficult and cumbersome task (Keys & Kennedy, 1999; Howes, 2002; Windschitl, 2002). In addition, teachers sometimes view inquiry as a step oriented approach to teaching. Similar to the scientific method, teachers feel that when implementing inquiry, they are losing the creative and imaginative component of science (Windschitl, 2002).

The majority of what teachers know about teaching is based on their own learning within a classroom setting. Given the traditional schooling that most teachers have been exposed to, many conceptions concerning the nature of inquiry have been formed. For example, teachers often believe that implementing and managing inquiry experiences within an elementary setting is too overwhelming and tedious. They also feel that teaching science as inquiry is possible only with above average students and therefore do not attempt to integrate inquiry into their regular education classrooms (Windschitl, 2002). If contemporary education reform is to be achieved, teacher educators must find ways to address and possibly alter these conceptions pertaining to the nature of inquiry.

One way to address these conceptions is to ensure opportunities for preservice teachers to experience inquiry as a learner. This notion is supported by Bandura's (1969, 1977, 1995, 1997) social learning theory. If teachers can experience positive inquiry learning experience first hand, they are more likely to replicate such experiences in their own classroom teaching. Windschitl (2002) conducted a research study to investigate experiences that could potentially encourage future science teachers to use inquiry-based instruction in their own classrooms. Specifically, he addressed the following questions:

1. How are preservice teachers' conceptions of inquiry related to the way they conduct and interpret their own independent inquiry?

2. What patterns emerge across participants in the ways in which they interpret their inquiry experience?
3. What conceptions and investigative experiences are linked with preservice teachers' use of inquiry in their own classrooms?

Participants within this study were enrolled in a secondary science methods course. A multiple-case study was chosen to qualitatively examine the research questions. Data sources consisted of references to their inquiry, reflective statements about inquiry, metacognitive statements indicating reflection on one's thinking, projections about future instruction stating disposition towards or plans for future instruction, and statements about students associated with projections about instruction (Windschitl, 2002, p.122).

Data revealed that initial conceptions related to the process of inquiry, were related to preservice teachers prior inquiry experiences (Windschitl, 2002). However, project experience within this study did modify these conceptions, even of those individuals who had a more sophisticated understanding of scientific investigation. In fact, individuals who had significant previous experiences with authentic science research, regardless of its placement on the continuum developed by science education researchers (as mentioned in Chapter 1), were the individuals who were more likely to use guided and open inquiry during their student teaching experiences. Based on these findings, it is clear how previous research experiences with inquiry can be powerful in determining the future use of inquiry methods by teachers within their classrooms.

A shift in traditional teacher and student roles also presents obstacles to inquiry oriented science teaching. Teachers typically perceive themselves to be the leaders in the classroom; however, when using an inquiry approach, it is often the students who emerge as the leaders. The student-centered approach of inquiry creates dilemmas about teacher and student roles (Keys & Kennedy, 1999). The unpredictability of instruction is often impacted by a teachers' limited understanding of learners. This then becomes yet another barrier to the implementation of inquiry in the science classroom.

In a recent study, Crawford (1999) investigated a preservice teacher's efforts to plan and implement inquiry-based instruction. Employing a case study approach, the researcher investigated the following research questions in an attempt to provide suggestions as to how teachers can be supported in the planning and implementation of inquiry-based instruction.

1. What were this preservice teacher's beliefs about science teaching?
2. In what ways did this preservice teacher engage her students in inquiry?
3. What factors supported or constrained this preservice teacher's ability to design and carryout inquiry-driven instruction?
4. What implications do these findings have for other preservice teachers?

Data sources included observations, interviews and conversations, as well as written work such as lesson plans, reflections and assignments. As a result of data collection, it was determined that the preservice teacher struggled with common pedagogical challenges; however, she did engage in practical inquiry. Although inquiry-based instruction is complex, the author provides five recommendations for supporting teachers in moving toward inquiry-based instruction. The first of these recommendations is for students to first explore their beliefs about science and about teaching. Because of the connection between beliefs and behavior, it is likely that a teacher's view of inquiry will contribute to his or her teaching of inquiry. This type of investigation or reflection is the first step in providing support for preservice teachers to address the complexities of teaching science as inquiry (Crawford, 1999).

The second recommendation is to provide preservice teachers with opportunities to participate in authentic investigations (Crawford, 1999). This idea again goes back to social learning theory in that if prospective teachers can experience positive inquiry learning experience first hand, they are then more likely to replicate such experiences in their own classroom teaching.

Providing models of teaching about scientific inquiry is also another powerful tool for supporting perservice teachers in the planning and implementation of inquiry-based instruction (Crawford, 1999). Just as experiencing inquiry first hand is important, seeing others implement inquiry-based instruction allows the preservice teacher to see the benefits as well as the challenges of an inquiry oriented teaching and learning.

The fourth recommendation is to provide scaffolding for preservice teacher in planning long-term units that relate to important questions and link to science content (Crawford, 1999). This recommendation is based on the notion that planning long term units provides easier connections to science content as opposed to short isolated lessons. This strategy will help preservice teachers see the “big picture” view of their teaching.

Finally, the fifth recommendation is to engage preservice teachers in collaborative inquiry of their own teaching (Crawford, 1999). As a result of her collaborative inquiry, the participant was able to more thoroughly reflect upon her own teaching. This proved to be a powerful tool in that it allowed her the opportunity to restructure her own understandings of learning and teaching (1999).

Although the unknown elements of inquiry teaching are especially challenging to plan for and implement for both preservice and seasoned teachers, with the proper support from teacher educators, supervisors and mentors, teaching science as inquiry is certainly an attainable goal (Crawford, 1999). Given the multiple factors that can contribute to the omission of the teaching of science as inquiry in the elementary classroom, teacher preparation programs as well as entire university communities need to take on the responsibility of restructuring teacher education to address these issues. For example, the notion of providing more science content knowledge for preservice teachers so that they may experience higher levels of self-efficacy in regard to the teaching of science, is something that is certainly an achievable objective. Nevertheless, it will require a collaborative effort among the multiple science departments as well as the education department. Significant contributions can be made to the restructuring of teacher education to combat these barriers to the teaching of science as inquiry; however, it will require a more holistic perspective rather than an isolated responsibility of the education department.

Self-Efficacy Defined

Given the centrality of beliefs as a vehicle for understanding teacher practice, it is helpful to draw on the work of Bandura (1977, 1986, 1997). Although research in efficacy can be traced back to Heider (1958), much of what is known about self-efficacy can be credited to Bandura (1977, 1986, 1997). The construct of self-efficacy is grounded in social learning theory and consists of two dimensions: personal self-efficacy and outcome expectancy. Bandura believes that both outcome expectations and personal self-efficacy influence behavior. Bandura defines personal self-efficacy as a judgment of one's ability to organize and execute given types of performances. On the other hand, outcome expectations are judgments one makes regarding the likely consequences such performances will produce (1977, 1986, 1995, 1997). The level of motivation and individual has, as well as their affective states and actions are based more on what they believe rather than on what is objectively true. "Unless people believe they can produce desired effects by their actions, they have little incentive to act" (1997, p.3). Bandura explains the varying effects of perceived sense of efficacy as follows:

> "A strong sense of efficacy enhances human accomplishment and personal well-being in many ways. People with high assurance in their capabilities in given domains approach difficult tasks as challenges to be mastered rather than as threats to be avoided. Such an efficacious outlook fosters intrinsic interest and deep engrossment in activities. These people set themselves challenging goals and maintain strong commitment to them. They heighten and sustain their efforts in the face of difficulties. They quickly recover their sense of efficacy after failures or setbacks. They attribute failure to insufficient effort or to deficient knowledge and skills that are acquirable. They approach threatening situations wit assurance that they can exercise control over them. Such an efficacious outlook produces personal accomplishments, reduces stress, and lowers vulnerability to depression" (1995, p.11).

On the other hand:

> "People who have a low sense of efficacy in given domains shy away from difficult tasks, which they view as personal threats. They have low aspirations and weak commitment to the goals they choose to pursue. When faced with

> difficult tasks, they swell on their personal deficiencies, the obstacles they will encounter, and all kinds of adverse outcomes rather than concentrate on how to perform successfully. They slacken their efforts and give up quickly in the face of difficulties. They are slow to recover their sense of efficacy following failure or setbacks. Because they view insufficient performance as deficient aptitude, it does not require much failure for them to lose faith in their capabilities. They fall easy victim to stress and depression" (1995, p.11).

These quotes from Bandura support the factors previously discussed, which contribute to the omission of science in the elementary classroom. Understanding the foundation upon which these quotes were built will help educators to more thoroughly understand why teachers choose to eliminate science from their curriculum, and how these obstacles can be overcome.

Social Learning Theory

Social learning theory was developed by Bandura (1969) as an extension to traditional behavioral learning theory. Bandura believes that learning is a process influenced by the interaction of cognitions, behaviors, and the environment. While most of the principles of behavioral learning theories are accepted, emphasis is placed on what an individual thinks about the consequences of behavior. Specifically, four principle concepts influence self-efficacy beliefs: mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states.

The most influential of the four is enactive mastery experiences. This is due to the fact that mastery experiences provide the most authentic evidence related to whether an individual can carry out what it takes to succeed. Mastery experiences are dependent upon the individuals' preexisting self-knowledge structures, the difficulty of the task, the amount of effort expended, the individuals' physical and emotional state, and the degree of external support received (Bandura, 1997). Success in mastery experiences increases efficacy appraisals whereas repeated failures will lower self-efficacy. In addition, the greater the self-efficacy, the more likely the participant will be to persist until success is achieved.

Vicarious experiences mediated through modeled attainments also influence efficacy appraisals. Hence, modeling serves as another effective tool for promoting a sense of personal efficacy (Bandura, 1997). By observing the rewards and punishments of the behaviors of others, individuals can decide to imitate, or not to imitate the behaviors based on the consequences received. When an individual observes a model with whom they identify in ability, they judge their own capabilities partly by comparing their performances with those of the model. In general, modeled successes by similar others raise observers' beliefs in their own efficacy, and modeled failures lower the observers' beliefs in their own efficacy. Although vicarious experiences are generally weaker than mastery experiences, vicarious experiences can override the impact of direct experiences in some cases (Bandura, 1997).

Verbal persuasion is another means through which efficacy beliefs can be strengthened. Verbal persuasion can be conveyed in ways that undermine a sense of efficacy or boost it. When individuals are verbally told that they possess the capabilities necessary to master given tasks, they are more likely to exude greater effort when difficulties arise. This verbal feedback in turn decreases the amount of time a person spends focused on self-doubt and/or dwelling on their personal deficiencies. Although verbal persuasion is widely used because of its convenience and accessibility, the success of this particular principle concept is dependent upon the credibility of those who are giving the verbal persuasion, as well as the way in which it is framed, structured, and delivered. Although verbal persuasion alone may be limited in its power to create enduring increases in perceived efficacy, Chambliss and Murray (1979a, 1979b) have found it to be most beneficial for people who have some reason to believe that they can produce desirable effects through their actions (as cited in Bandura, 1997).

The fourth principle concept to influence self-efficacy beliefs is physiological and emotional states. People often interpret their physiological activation in situations to be indicators of vulnerability. Due to the fact that high arousal can often times debilitate performance, individuals are more inclined to expect success in situations when they are not experiencing extreme stress in association with the task or action to be achieved. More specifically, individuals with a high sense of self-efficacy can find a heightened sense of arousal as motivating, while those with a lower sense of self-efficacy may experience fear or anxiety which may prevent them from completing or even attempting the performance (Bandura, 1997).

Although the aforementioned principle concepts influence people's beliefs about their personal efficacy, they only constitute the environmental events that impact efficacy. These efficacy beliefs information sources do not automatically influence self-efficacy but regulate them through four major processes. A substantial body of literature shows that efficacy beliefs regulate human functioning through cognitive, motivational, affective, and selective processes. These are the processes through which efficacy beliefs produce their effects. Rather than acting independently, each of these four processes operate in concert to regulate human functioning (Bandura, 1977, 1981, 1982, 1989, 1995, 1997).

Cognitive processes encompass two components: cognitive constructions and inferential thinking. Most people's actions are first shaped in their thought. Cognitive constructions serve as guides for action in the development of proficiencies (Bandura, 1997). Through this process, individuals cognitively construct future situations in their mind based on their perception of their efficacy. People's beliefs about their efficacy influence how they visualize the futures they construct (Bandura, 1997). More specifically, those who have a high sense of efficacy tend to view situations as realizable opportunities. They see scenarios of success, which provide the positive guides useful for performances. On the other hand, those individuals with a low sense of efficacy, view themselves as ineffective and therefore interpret situations as risky. In turn, these individuals are inclined to visualize failure scenarios (Krueger & Dickson, 1994, as cited in Bandura, 1997).

Inferential thinking is thought to enable people to predict the likely outcomes of different courses of action. To infer these outcomes, problem-solving skills are required. "People must be able to draw on their preexisting knowledge to construct options, to weigh and integrate predictive factors into composite rules, to test and revise their judgments against the immediate and distal results of their actions, and to remember which factors they have tested and how well they have worked" (Bandura, 1997, p.117). To complete this complex task, it requires a strong sense of efficacy. If an individual has a low sense of efficacy it is likely that they will not have the motivation to remain task oriented in the face of ambiguities, situational demands, and judgment failures (1997).

The second internal process that determines one's self-efficacy beliefs is motivation. Three different forms of cognitive motivators have been identified: attribution theory, expectancy-value theory, and goal theory. According to Weiner (1985), attribution theory refers to retrospective judgments of the causes of one's performances" (as cited in Bandura, 1997, p.123). A person with a high sense of efficacy tends to credit their successes to personal capabilities and their failures to insufficient effort. This is important for efficacy in that these types of individuals will embark upon a difficult task and persist in the face of adversity. Expectancy-value theory assumes that motivation is derived from the expectation that a particular action will produce specified outcomes. Some people motivate themselves by the outcomes they expect to receive when completing a particular behavior.

The third form of cognitive motivators that is seen to influence self-efficacy beliefs is goal theory. Goal theory purports that motivation is derived from setting challenging goals. Locke and Latham (1990) as well as Mento Steel and Karren (1987) have supported the idea of goal theory through an extensive line of research (as cited in Bandura, 1997). This research provides evidence that challenging standards enhance motivation.

Affective processes also play a role in regulating the formation of a person's beliefs. The emotions that an individual with a low sense of efficacy may experience during certain situations, such as anxiety, depression and fear, will cause them to protect themselves from similar contexts. On the other hand, an individual with high self-efficacy will attempt to become more proactive in changing their affective states (Bandura, 1969, 1977, 1995, 1997).

The final process through which efficacy beliefs can be influence is the selection process. The selection process is based on the idea that a person can select their environment based on their beliefs of their personal capabilities. As a result of this process, individuals choose activities based on what they perceive themselves as being capable of completing, and avoid activities they feel will make them vulnerable. People of high efficacy prefer difficult activities and also display high "staying power in those pursuits" (Bandura, 1997, p.160). People with a low sense of efficacy tend to avoid difficult situations and typically view these situations as being threatening. The important idea here is that the beliefs of personal efficacy can shape and determine an individual's life by influencing the types of activities and environments with which people choose to become involved.

Each of these cognitive processes is important because they can enhance or undermine efficacy. Bandura's construct of self-efficacy evolved from the social learning theory and addresses the idea that self-efficacy beliefs influence how people think, act, feel and motivate themselves in relation to all aspects of their lives (1995, 1997). As a result, such beliefs are believed to have predictive values, hence when applied to the context of education, they guide teaching behaviors and practices that are undertaken, as well as how effectively they are performed. This idea is important for this study because if self-efficacy can in fact be influenced, teachers could achieve at levels to which they once viewed as unattainable.

Self-Efficacy Applied to Education

Many researchers have attempted to apply Bandura's work to education. The first instrument developed to measure teacher self-efficacy beliefs was developed in the mid-

1970's by the Rand Corporation. This instrument was administered by Armor (1976) and Berman and McLaughlin (1977) and consisted of two Likert Scale items:

1. When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance depends on his or her home environment.
2. If I really try hard, I can get through to even the most difficult or unmotivated students. (p. 159-160).

Teaching efficacy on this instrument measured the belief that teachers in general could influence student performance. This concept is represented in the first item of the RAND study (Berman & McLaughlin, 1977). Personal efficacy, a teachers' belief about their own ability, is measured through the second RAND item (1977). These two dimensions, as with personal self-efficacy and outcome expectancies, were also thought to be independent but related.

Both Armor (1976) and Berman & Mclaughlin (1977) defined teacher self-efficacy as "the extent to which the teacher believed he or she had the capacity to affect student performance" (Berman & McLaughlin, 1977, p.137). As a result of administering this instrument to Los Angeles minority schools, Armor (1976) concluded that there was in fact a positive relationship between teacher efficacy and student achievement associated with reading. In addition, Berman and McLaughlin also found a positive correlation between teacher's self-efficacy beliefs and improved student performance, the number of project goals and the amount of teacher change (1977).

Shortly after the first Rand study, Guskey (1982) developed a 30-item instrument measuring responsibility for student achievement (RSA). This instrument assessed teachers' beliefs associated with events. Teachers were asked to complete a short questionnaire. One section of the questionnaire directed the teachers to divide 100 points among four probable causes or reasons for a classroom situation in which they were (a.) particularly successful with a group or class of students and (b.) particularly unsuccessful with a group or class of students (1982, p.72). The four probable causes related to their specific teaching abilities were, the effort put into teaching, the difficulty of the task, and good or bad luck. In addition, Guskey also included the two Rand items in an attempt to determine an overall estimate of each teacher's personal sense of efficacy. A 7-point Likert scale from strongly agree to strongly disagree was used to rate each of the statements.

Specifically, Guskey was looking to determine if teachers attributed the occurrence of a particular event to be as a result of the teacher or factors outside of the teacher's control. Overall, the results indicated that teachers do use different casual attributions when explaining positive and negative learning outcomes on the part of their students. When success was experienced, teachers generally attributed the success to the internal attributions of ability and effort. When unsuccessful with a class, the greatest emphasis was placed upon external attributions. Teachers also tended to emphasize insufficient effort in comparison to deficient teaching abilities. However, when comparing elementary teachers to secondary teachers, elementary teachers tended to attribute their lack of success to internal causes much more than secondary teachers. Guskey hypothesed personality differences between elementary and secondary teachers, to be a possible reason for this difference. He also stated that the difference could be specific to the teaching situation in that secondary teachers teach older students whose learning patterns are more firmly established, and therefore more difficult to change.

In regard to teaching efficacy, Guskey (1982) found only two of the attribution categories in Weiner's model (1972) to be responsible for influencing personal efficacy: the internal/unstable category of effort and external/stable category of task difficulty (as cited in Guskey, 1982). Although this study was positively correlated with earlier efficacy scales, no other researchers adopted this measure for further research.

At about the same time as Guskey's study, Rose and Medway (1981) developed the Teacher Locus of Control (TLC) Scale. The TLC was designed to measure elementary school teachers' perceptions of control in the classroom through the use of 28 forced-choice items. This measure was different than the measure before it, in that it was more specific to a teaching context and captured both internal and external responsibilities for student successes or failures. For example, half of the items on the TLC described situations of student success, and the other half described failures. For each of these items, one of the explanations was attributed to the teacher and the other assigned responsibility outside of the teacher's control, usually the student. Although this study has not been utilized by the research community, Rose and Medway (1981) did find it to be an effective predictor of teacher behaviors.

Data analysis results as well as classroom observations indicate that the TLS was a viable method for assessing teachers' perceptions of control within the classroom environment (Rose & Medway, 1981). Additionally, the TLC scale was found to be predictive of teacher and student behavior. Although this research was significant during its time, researchers such as Ashton and Webb (1982) and Denhman and Michael (1981) were critical of this work. Their stance toward these findings was maintained by their belief that the questions on the instrument were not based on Bandura's concept of self-efficacy. Instead, they believe that these studies explored Rotter's (1966) theory of locus of control. As a result of their viewpoint, each developed their own line of research to further explore their ideas.

Denhan and Michael (1981) developed a multidimensional model of teacher efficacy beliefs based on Bandura's conception of self-efficacy. This study provided a model for relating sense of efficacy to other variables. The three major components within this model are teacher sense of efficacy, its antecedents, and consequence conditions. The researchers used twenty teachers and defined teacher's sense of self-efficacy as "…an intervening variable that mediates the relationship between antecedents (teacher training, teaching experiences, system variables) and personal variables and consequence, (teacher behavior and student outcomes)" (as cited in Riggs, 1988, p.29). Denhan and Michael's (1981) assertion was that a teacher's sense of efficacy may be both a causal and resulting factor. This has importance because if this assertion is in fact true, a teacher's sense of self-efficacy can not only affect student outcomes, but student outcomes can also affect a teacher's sense of self-efficacy. With this study of teacher sense of efficacy, Denhan and Michael added structure to a relatively new area of inquiry (1981).

During the same time period, Ashton and Webb's (1982) work focused on clarifying the nature of the teachers' sense of efficacy construct. The goal with this study was to "extend the measure of teacher efficacy while maintaining a narrow conceptualization of the construct" (Tschannen-Moran and Hoy, 2001, p.787). More specifically, they worked to provide support for the two dimensions of self-efficacy described by Bandura (1977, 1986, 1997): personal self-efficacy and outcome expectancy. Ashton and Webb were also among the first researchers to develop a multidimensional model of teacher efficacy. Later, Ashton, Webb, and Doda (1983) determined that a positive relationship did exist between teachers' sense of self-efficacy and student outcomes (as cited in Ashton, 1985).

Up until this point, most of the research associated with self-efficacy has been focused on teaching in general terms. The instruments previously mentioned deal only with the general process of teaching, ignoring Bandura's assertion that self-efficacy is a situation specific construct. The following review will address how self-efficacy has been measured within the specific construct of science education.

Self-Efficacy within the Context of Science Education.

In order to more fully address the idea that teacher efficacy is context specific, Aston, Buhr, and Crocker (1984) developed a series of vignettes (as cited in Tschannen-Moran and Hoy, 2001). These vignettes describe situations a teacher would be likely to encounter, and then asks the teacher to make judgments regarding their effectiveness in handling the situations. For example, a sample item is as follows:

> "A small group of students in constantly whispering, passing notes and ingnoring class activities. Their academic performance on tests and homework is adequate and sometimes even good. Their classroom performance, however, is irritating and disruptive. How effective would you be in eliminating their disruptive behavior?" (as cited in as cited in Tschannen-Moran and Hoy, 2001, p.788).

Although this instrument was useful in that it addressed the assumption that teacher efficacy is context specific, it did not receive wide acceptance and has not been used in any other research studies.

Drawing upon this work, Gibson and Dembo (1984) developed and validated the Teacher Efficacy Scale (TES), a questionnaire of thirty items using a six-point Likert scale. This instrument was designed to measure teachers' self-efficacy beliefs by addressing the areas of teachers' effort, skill, training and experience. When administered to 208 elementary school teachers, the results revealed two distinct factors, which later became labeled personal teaching efficacy (PTE) and general teaching efficacy (GTE). Personal teaching efficacy was thought to correspond with Bandura's notion of self-efficacy in that it assessed a teachers' belief in their own abilities to bring about student change. On the other hand, general teaching efficacy was reflective of outcome expectancy and was said to measure the degree to which the environment could be controlled. Other studies using the TES, however, resulted in inconsistencies and caused researchers to question the validity of various items. While the TES was believed to measure both GTE and PTE, other research did not substantiate this distinction. The TES was criticized for not clearly capturing the dimension of personal efficacy as described by Bandura's definition of the self-efficacy construct. In addition, similar to the Rand instrument, the TES instrument developed by Gibson and Dembo was a global measure of the two efficacy factors. This caused concern because it was not consistent with Bandura's conception of efficacy as a situation-specific construct. This concern later fueled future work to further develop situation specific self-efficacy instrument.

To add to the literature base on self-efficacy with attention to a Bandura's description of a situation specific construct, Riggs (1988) extended the work of Gibson and Dembo (1981). Riggs developed and validated an instrument to measure teachers' personal self-efficacy and outcome expectancy beliefs for science teaching and learning. This instrument was entitled the Science Teaching Efficacy Beliefs Instrument (STEBI). The STEBI was a 25-item, 5-choice, Likert-type scale for inservice teachers. It consisted of two scales that were consistent with Bandura's theory (1977). The two scales were entitled Personal Science Teaching Efficacy Belief Scale (self-efficacy dimension) and Science Teaching Outcome Expectancy Scale (outcome expectancy dimension) (Enochs & Riggs, 1990). Results indicates that the STEBI is an effective measurement tool which can be used to further investigate teachers' beliefs toward science teaching and learning.

This work by Riggs was further extended by Enochs and Riggs, (1990), to address preservice elementary science teachers' self-efficacy. This instrument was entitled Science Teaching Efficacy Belief Instrument for prospective teachers (STEBI B). In order to accomplish this task, the Riggs (1988) Science Teaching Efficacy Belief Instrument Form A (STEBI A) was modified from an inservice orientation to that of preservice. Items were reworded in the future tense to allow for the construct to be viewed in a different situational context (Enochs and Riggs, 1990). Both the STEBI A and the STEBI B have become widely used in science education to inform teacher educators about the science beliefs of prospective teachers.

More recently, Tschannen-Moran and Woolfolk Hoy (2001) attempted to begin work on a new measure of efficacy. This new measure, named the Ohio State teacher efficacy scale (OSTES), is said to be "…superior to previous measures of teacher efficacy" (2001, p.801). This statement is based on the assertion that the measure captures a broad range of capabilities necessary for good teaching. However, it is not so specific that it renders itself useless for comparison of teachers in different domains or contexts.

The OSTES is an instrument that has been refined to include a long form (24 items) and a short form (12 items). Each item on the instrument is said to measure important tasks or elements of teaching. "A 9-point scale was used for each item, with anchors at 1 – nothing, 3 – very little, 5 – some influence, 7 – quite a bit, and 9 – a great deal" (Tschannen-Moran & Hoy, 2001, p.796). Both forms are considered to be reasonably valid and reliable. The researchers assert that this measure moves beyond previous measures to capture a wide range of teaching tasks. In addition, this instrument is unique in that it addresses a broad range of teaching tasks including assessment, meeting individual student needs, motivating student engagement and interest as well as addressing student misconceptions.

Improving Elementary Science Education

In light of the omission of science from the elementary classroom, as well as the disconnect between reform efforts and actual classroom practice, a number of science teacher educators have attempted to change teachers practices through teacher education. This however, has met with limited success. One possible solution for improving teacher education is to offer a stronger foundation of science content (Ernst, 1994). This is accomplished through requiring preservice teachers to take more science content courses. The solution is based on the idea that the more science courses one has, the better one will be at teaching science. However, the inclusion of more content courses alone does not necessarily translate into a better understanding of science, nor does it reflect a more effective understanding of how to represent content to learners (Zembal-Saul, Blumenfeld, & Krajcik, 2000). For example, in a study by Dobey and Schafer (1984), teachers with superior knowledge did not exhibit more inquiry teaching behaviors as compared to their minimal science knowledge counterparts. Dobey & Schafer (1984) suggest a possible reason for this finding is connected to the preservice teachers use of instructional time. Research indicated that the preservice teachers with superior knowledge tended to use instructional time to provide children with verbal explanations rather than allowing the students to formulate their own explanations based on evidence. This time spent explaining scientific phenomena detracted from the time that could have been spent with children investigating scientific phenomena in an attempt to formulate their own explanations.

In addition, when required to take more college science courses to address the concern of preservice teachers having little knowledge of science content and science processes, Shrigley (1974) found only a low correlation between science concept knowledge and self-efficacy. Furthermore, Feistritzer and Boyer (1983) found no relationship between the number of science courses and preservice teachers' attitudes toward science. In addition, Stephans and McCormack (1985) as well as Wenner (1993) actually found a negative correlation between science concept knowledge and self-efficacy. However, when preservice teachers were enrolled in science courses specifically designed for elementary teachers, Westerback and Long (1990) found that teacher anxiety about teaching science decreased. Additionally, McDevett et al. (1993)

found similar results when preservice teachers were enrolled in specially designed and coordinated science and education courses (as cited in Schoon and Boone, 1998).

In addition, programs and courses have been developed to support prospective elementary teachers in developing their knowledge about scientific content and inquiry (Zembal-Saul, Blumenfeld, & Krajcik, 2000). Research has demonstrated that elementary science methods courses can begin to overcome some of the difficulties preservice elementary teachers' experience as a result of their negative prior experiences with science as well as poor science courses (Rice & Roychoudhury, 2003). As a result of this research, many science educators have proposed the elementary science methods course as a vehicle for change (Abell & Bryan, 1997; Koballa & French, 1995, Rice & Roychoudhury, 2003).

Koballa and French, (1995) for example, conceptualized and implemented a science methods course that addressed preservice elementary teachers' needs and concerns about science teaching and learning. Together with the students, the researchers negotiated all aspects of the course, from the syllabus to the assessment strategies. "The atmosphere of the course; through negotiation, collaboration, and discussion; offered time and an open forum for participants to view more critically what was taught how it was taught, and what was being learned" (1995, p.63). Although several dilemma's were encountered, decisions were made using multiple data sources. Data collections included file notes, audiotaped sessions, personal journals, semi-structured interviews, and informal interviews with the students. Overall, preservice teachers were granted the opportunity to take responsibility for their own learning and as a result, they were able to think about teaching and learning in a new way as a result of their participation in this innovative science methods course.

Likewise, in a study where a life science course was designed specifically for prospective elementary teachers, the prospective teachers were able to develop a more appropriate conception of science and school science as a result of their experiences (Haefner & Zembal-Saul, 2001). The prospective teachers in this study entered the course equating science with the natural world. Furthermore, they describe participation in science as “figuring out how the world works” (p.17). Throughout the course of the semester, the preservice teachers experienced a shift in their thinking as a result of their experiences in the class, and came to view science as a process. As a result, their views pertaining to science became more focused on experimentation.

Similarly, Lee and Krapfl (2002) investigated the effects of the Basic Science Minor program to ascertain the similarities and differences between program graduates and their teacher colleagues. The Basic Science Minor program was initiated in 1988 and represented a total program effort to alter the way elementary science was taught. Specifically, this approach modeled advocated teaching approaches while enhancing content knowledge, facilitating positive attitudes, and provided a cohesive experience in teaching science (2002). Essentially, this program prepares elementary majors with a strong content background, the pedagogical tools to teach inquiry-oriented science, and an attitude and orientation towards science and teaching science that serves them well as future elementary science educators. The findings from this study indicate that the Basic Science Minor program has been effective in preparing its graduates to teach elementary school science. Furthermore, “graduates understand and attempt to utilize hands-on science and the learning cycle. They have a very positive attitude toward teaching science, are confident as science teachers, and persist in spite of several constraints" (p.261).

Another goal of teacher preparation programs is to provide preservice teachers with opportunities to experience science as a hands-on inquiry-based process. As a result of a examining the relationships between individuals' conceptions, plans and actions regarding inquiry, Windschitl (2002) proposes that independent science investigations be part of preservice education. These investigations allow students the opportunity to experience the excitement and enthusiasm, as well as the complexities and dilemmas inherent with the inquiry process. Although all of the preservice teachers did not choose to include inquiry in their classrooms during student teaching, these experiences were valuable in that they provided a foundation for these future teachers to begin. More specifically, students with previous inquiry experience are more likely to implement inquiry instruction in the classroom (2002). In addition, another means for addressing hands-on inquiry based opportunities for preservice teachers is through problem-based science (PBS). PBS provides preservice teachers the opportunity to find solutions to real problems by asking and refining questions. During PBS, students design and conduct investigations, gather and analyze information and data, make interpretations, draw conclusions, and report findings (Schneider, Krajcik, Marx & Soloway, 2002). As a result of their experiences with PBS, students are exposed to successful hands-on inquiry experience, which may translate into the future use of inquiry experiences in their own classroom practices (Ginns & Watters, 1999; Windschitl, 2002). In summary, science courses in preservice programs must provide more authentic practices and experiences for prospective elementary science teachers if the vision of educational reform is to be actualized (1999).

Because inquiry projects alone do not ensure a feeling of competence for preservice teachers in regard to the implementation of inquiry into classrooms, reflection has also been advocated within teacher preparation programs. Reflection has been seen as a primary method by which novice teacher can construct a receptive knowledge base for teaching (Wallace & Oliver, 2003; Zembal-Saul, Blumenfeld, & Krajcik, 2000; Windschitle, 2002).

In a recent study, Wallace and Oliver (2003) investigated the journaling habits of perservice science teachers. Through the use of a matrix, the researchers tracked journaling change over time. This two dimensional matrix acted as a guide for the preservice teachers during reflection; however, topics were of their own choosing. Through the course of a semester, preservice teachers tended to expand their levels of reflection as well as their reflection interests (2003). Similarly, Zembal-Saul, Blumenfeld, & Krajcik, (2000) utilized reflection for strategically assisting in the development of more sophisticated views of inquiry. The researchers indicated improvements in the complexity of reflection as a result of including guided reflection into cycles of instruction. Windschitle (2002) also found that the use of structured reflections required students to reflect on key aspects of students' experiences but also challenged the students' world views.

Findings from these studies indicate that journaling can enable preservice teachers to move beyond the more superficial features of their practice and instead, reflect upon children's ideas and thinking. Students moved from a general or superficial sense of reflection to one with deeper levels of analysis/synthesis and evaluation (Wallace & Oliver, 2003). In addition, the preservice teachers moved away from technical interests towards more personal and problematic interests. Based on these research studies, the experience of journaling within a teacher preparation setting promotes the progression of thinking levels from more superficial concerns to deeper concerns (Zembal-Saul, Blumenfeld, & Krajcik, 2000; Windschitl, 2002; Wallace & Oliver, 2003).

Another aim of teacher preparation is to assist preservice teachers in developing pedagogical content knowledge (PCK). Research findings indicate that preservice teachers have limited PCK (Haefner & Zembal-Saul, 2001). PCK as defined by Shulman (1986) refers to the knowledge that is unique to making subject matter more comprehensible to others. As a result of a recent research study, Zembal-Saul, Blumenfeld, & Krajcik (2000), developed a framework for promoting the development of preservice teachers' PCK. Through the use of content representation, which the authors define as a subset of PCK for science teaching, the researchers were able to support elementary science teachers learning across time. While in and of itself, subject matter knowledge is insufficient for teaching for understanding, the role of robust subject matter knowledge is seen as central to developing PCK and teaching for understanding (Haefner & Zembal-Saul, 2001).

Research Associated with Teaching Science as Inquiry

Although much research has been done to improve teacher education as well as the teaching of science as inquiry within the elementary classroom settings, the focus of most research studies has been on practice; however, little is known about self-efficacy beliefs. Much of the research associated with inquiry deals with the teachers' views of inquiry and how they implement inquiry with their students. Although this type of analysis is useful, it overlooks how a teachers' self-efficacy may impact the implementation of inquiry experiences in their classrooms.

For example, Keys and Kennedy (1999) utilized an interpretive paradigm to investigate how a particular teacher interpreted teaching science as inquiry. They also attempted to construct a context specific theory of the teachers' inquiry teaching. In addition, they investigated the challenges the teacher faced while implementing inquiry as well as the ways in which she attempted overcome these challenges. To gather and analyze data, the researcher utilized multiple sources of data, which included filed notes, observations, and formal interviews with the teacher as well as the students. Although this study provided valuable information pertaining to a particular teachers style of implementation, it did not address the possible connection between the teacher's self-efficacy and her choices and actions within the classroom.

Similarly, in a study by Crawford (1999), the researcher investigated the implementation of inquiry as well as the factors that supported or constrained the preservice teacher's ability to design and carry out inquiry-driven instruction. Data was gathered and analyzed using classroom observations, handwritten and videotaped records of lessons, semi-structured interviews, informal conversations, written reflections, interviews of students, as well as students' final written reports and videotaped presentations. Although data analysis was very thorough and used a multitude of data sources, again, this study did not investigate how the teacher's self-efficacy may have contributed to the beliefs and actions of this preservice teacher.

Ginns & Watters (1999) also investigated the practice of beginning teachers. The researchers focused on the behaviors and experiences of beginning teachers as they taught elementary science for the first time. To examine data, the researchers used a multiple-case study approach and utilized observations, interviews, and recording of teacher behaviors in science. Unlike the previously mentioned studies, Ginns & Watters employed both a qualitative and quantitative approach for collecting data. The STEBI B was used within this study to examine preservice teachers' self-efficacy in relation to the teaching of science. Although the STEBI B has been proven to be a valid and reliable instrument, it does not address the issues surrounding the contemporary reform of science education, which was taking place at the time of this research. Nevertheless, the researchers were able to examine changes in perservice teachers beliefs about the teaching of science.

More recently, Windschitl (2002) examined how preservice teachers' inquiry experiences in a science methods course, influenced and were influenced by their conceptions of inquiry. To gather data, the researcher utilized a multiple-case study approach. Observations as well as written work, reflective journals and interviews were analyzed for thematic content. Although this study did investigate how these experiences were associated with eventual classroom practice, it did not examine the possible correlations between self-efficacy and teaching behaviors.

Significance of the Study

Although various researchers have set out to improve teacher education in admirable ways, few of these attempts have involved the relationship between self-efficacy beliefs and practice. Recalling Bandura's (1977, 1986, 1995) assertion that self-efficacy beliefs have a powerful influence over one's behavior, it is important for teacher educators to further investigate the influence of teacher beliefs on classroom practice. Additionally, given the current trend of contemporary science education reform, there is not an instrument to measure self-efficacy and its impact on the teaching of science as inquiry.

Given what is known about the interrelatedness of beliefs and practice, and the lack of attention placed on investigating how self-efficacy may impact teacher practice, this study is aimed at further investigating the situation specific construct of self-efficacy to include the teaching of science as inquiry. Theory purports that individuals tend to act according to their beliefs. Bandura (1977, 1986, 1989, 1995, 1997) asserts that the decisions people make and the associated actions are a direct result of one's beliefs. Hence, the beliefs that teachers hold concerning the teaching of science as inquiry are at the core of educational change.

As such, by developing, validating and establishing the reliability of an instrument to measure self-efficacy beliefs of preservice elementary teachers with regard to the teaching of science as inquiry, the current reform efforts will also be addressed. This instrument will provide a foundation through which researchers can identify certain individuals and investigate the connections between their beliefs and actual teaching behaviors and classroom practices. Through the completion of more extensive research coupled with this instrument, science educators may come to more clearly understand the connection between teacher beliefs and the teaching of elementary science as inquiry.

Chapter 3

Methodology

Purpose and Guiding Questions

The purpose of this study was to develop an instrument to measure preservice teachers' perceived self-efficacy in regard to the teaching of science as inquiry. The instrument, Self-Efficacy Beliefs in Regard to Supporting Students in Learning Science as Inquiry (TSI), was based upon the work of Bandura (1977, 1986), Riggs, (1988), and Enochs & Riggs (1990).

Instrument Validity and Reliability

The development of a valid and reliable instrument is a complex and systematic process. The process begins with the definition and clarification of the construct to be assessed and continues through item pool preparation, item refinement, and selection based upon field test data, and study of the instrument's reliability and validity. (Borg & Gall, 1989; Nunnally, 1970; Rubba & Andersen, 1978; Popham, 2000).

Validity

Validity refers to "the methodological and/or conceptual soundness of research" (Grazioano and Raulin, 2000, p. 436). The Standards for Educational and Psychological Testing refers to validity as "the appropriateness, meaningfulness, and usefulness of the specific inferences made from test scores. Test validation is the process of accumulating evidence to support such inferences" (American Psychological Association, American Educational Research Association, & National Council on Measurement in Education, 1985, p.9). The importance of validity is apparent. According to the Standards for Educational and Psychological Testing “validity is the most important consideration in test evaluation” (p.9). In fact, Nunnally (1970) states that determination of validity is a crucially important phase in the development of a measuring instrument to determine if it is useful for any purpose” (p. 132). Thus validity must be a primary concern throughout the process of instrument development. The content of an instrument must be systematically examined to determine if it in fact covers a representative sample of the behavior domain purported to be measured (Nunnally, 1976; Anastasi & Urbina, 1997; Popham, 2000).

To determine instrument validity, the American Psychological Association has defined guidelines. These guidelines identify the four primary types of instrument validity: content, concurrent, predictive and construct (Isaac & Michael, 1997; Popham, 2000). Content validity relates to how well the content of the instrument samples the subject matter about which conclusions are to be drawn. It is the “degree to which the sample of test items represents the content that the test is designed to measure” (Borg & Gall, 1989, p. 258). When developing the TSI, the items needed to be representative of the two dimensions of the self-efficacy construct as defined by Bandura (1977); personal self-efficacy and outcome expectancy. In addition, the items on the TSI also needed to be representative or appropriate to teaching science as inquiry.

Predictive validity, one form of criterion validity, relates to the effectiveness of a test in predicting an individual’s performance in specified activities. Concurrent validity, a second form of criterion validity, on the other hand does not necessarily predict performance on the same criterion at a later date; however, it does addresses the effectiveness of an individual's status on criterion data collected concurrently with another test (Kerlinger and Lee, 2000).

Construct validity, determines the degree to which certain explanatory concepts or constructs account for performance on the test. (Graziano and Raulin, 2000; Anastasi & Urbina, 1997; Isaac & Michael, 1997). According to Anastasi and Urbina (1997), construct validity is "the extent to which the test may be said to measure a theoretical construct or trait" (p.126). It is a theoretical construction about the nature of human behavior" (Standards for Educational and Psychological Testing: AERA-APA—NCME, 1985 as cited in Borg and Gall, 1989, p. 255). Construct validity in essence attempts to validate the theory behind the instrument. Self-efficacy according to Bandura (1997) is a construct that can be delineated into two dimensions: personal self-efficacy and outcome expectancy. Personal self-efficacy relates to a persons judgment of their own capabilities to organize and execute courses of action required to achieve designated types of performances. Outcome expectancy, on the other hand, is a person's judgment of the likely consequence such performances will produce. In relation to the TSI instrument, personal self-efficacy is associated with preservice teachers' judgment of their ability to teach science as inquiry; whereas, outcome expectancy is associated with preservice teachers' expectations regarding the consequences of their own behavior/performances (1997).

Reliability

Reliability or consistency is a necessary property for any measurement procedure. Thorndike (1991) refers to reliability as how accurately the test measures what it purports to measure. Reliability refers to "the degree to which test scores are free from errors of measurement" (Standard for Educational and Psychological Testing, 1985, p.9). According to Graziano & Raulin (2000), the factors that contribute to the reliability of an instrument's score include: 1) the precision and clarity of the operational definition of the construct; 2) the care with which we carry out the measures and the precision with which we follow the procedures outlined in the operational definition; and 3) the number of independent observations on which the score is based (p.6). The overall goal in determining the reliability of an instrument is to minimize the errors in measurement. If an instrument yields low reliability scores, there are a number of factors that may contribute to this inconsistency. These include such factors as: a) response variation by the subjects; b) variations in test content or the test situation; c) variations in administration; and d) variations in the process of observation (Isaac & Michael, 1997, p.135). Nunnally (1970) groups these various types of inconsistencies into two categories: "internal" sources of error and "external" sources of error.

To examine the reliability of the TSI instrument score the Cronbach's coefficient alpha and the test-retest method were used. The Cronbach's coefficient alpha, which examines internal consistency, is often employed in educational and psychological instrument that do not use dichotomous items. The coefficient alpha measures the intercorrelation of the items (internal consistency). The more intercorrelated the items, the higher the internal consistency coefficient (Anastasi & Urbina, 1997; Thorndike, 1997; Graziano & Raulin, 2000). Alpha coefficients range in value from 0 to 1. The higher the coefficient value, the more reliable the score generated from the instrument. Nunnaly (1970) has indicated 0.7 to be an acceptable reliability coefficient but lower thresholds are sometimes used in the literature (as cited in Santos, 1999, p.2). Reliability coefficients above .90 are considered necessary to make individual decisions with instrument alpha values; above .80 are considered acceptable for research; and above .70 for initial group decisions that will be tested through additional means (Nunnally, 1970: Sax, 1974; Nunnally, 1978).

The test-retest method is a technique used for assessing the external consistency of an instrument. When using this method, a specified test is given at two different times. The scores on these two tests are then correlated to determine the reliability of scores (Thorndike, 1997; Anastasi & Urbina, 1997). A time interval of at least six weeks is suggested between each administration of the test (Borg, & Gall, 1996). For the purposes of this study, a single group, test-retest method was used. A Cronbach Alpha was then completed to determine the reliability of the scores from each test. Details regarding the results for this process are reported in Chapter 4.

Participants

The participants for this research were Pennsylvania State University students enrolled in the SCIED 458 course: Teaching Science in the Elementary School. The TSI instrument was administered to the 190 prospective elementary school teachers in all six sections of SCIED 458, including students enrolled in a professional development school setting, during the week of September 8, 2003, and then again during the week of December 1, 2003. This group of participants represents the intended target population for the final instrument. The intended population would therefore include preservice elementary science teachers and beginning practicing science teachers.

The Pennsylvania State University teacher preparation programs, including the Elementary-Kindergarten Education Program (EK ED) is accredited by the National

Council for Accreditation of Education (NCATE) and approved by the Pennsylvania Department of Education. The EK ED program is a contemporary elementary teacher education program that prepares kindergarten through grade six teachers to work in a wide variety of elementary school settings, e.g., public/private/rural/suburban/urban. It is situated in a conceptual framework that consists of the following five elements:

1) Educators are lifelong learners
2) Educators understand how students develop and learn
3) Educators possess discipline knowledge and pedagogical understanding
4) Educators manage and monitor learning and development
5) Educators are members of the learning communities.

A copy of the EK ED conceptual framework can be found at http://www.ed.psu.edu/general/ncate/framework.htm.

The Pennsylvania State University-State College Area School District Elementary Professional Development School (PDS) http://www.ed.psu.edu/pds/ is a collaborative program involving preservice teachers, veteran teachers, administrators, and university faculty working together to accomplish three goals:

1) To enhance educational experience for all children
2) To ensure high quality induction into the profession for new teachers
3) To engage in furthering the professional development of veteran teachers and teacher educators.

The Pennsylvania State University, its College of Education, and Department of Curriculum and Instruction joined in partnership with the State College Area School

District to create a special opportunity for Penn State prospective elementary school teachers. This partnership offers undergraduate elementary education majors an opportunity to pursue an intensive field-based alternative for completion of their teacher preparation program. In line with national movements in education, prospective elementary teachers, who choose this alternative, work to complete 30-credits of coursework as they teach on-site in an elementary school throughout their senior year. The work in a Professional Development School is designed to immerse the prospective teacher into the schools culture, develop deeper understanding of student learning, and create a wider experience base from which the prospective teacher can draw when they enter the profession as a first year teacher.

The entry requirements for the EK ED and PDS programs can be found at the following websites: http://www.ed.psu.edu/edservices/certification/ent_criteria.html and http://www.ed.psu.edu/pds. Specifically, the prerequisites for entrance into SCIED 458: Teaching Science in the Elementary School, consist of the successful completion of three previous science courses, one in each of the three domains of Biological, Earth and Physical Science. All prerequisite courses must be equivalent to three credits and one of the three science courses taken must be a laboratory course. The science courses that may be used to fulfill the requirements can be found at http://www.ed.psu.edu/ci/teachered/scied_prer.asp or http://www.psu.edu/bulletins/bluebook/gened/gn.html as well as in Appendix A.

A consent form was given to all participants at the initial time the instrument was administered (Appendix B). Instructions on how to complete the instrument and the purpose of the study were provided verbally by the investigator before the administration of the instrument. All subjects received the same instructions in a university classroom setting.

Development of the TSI

A 13-step process was utilized to complete this study. This 13-step plan described below was used to develop and build validity and reliability for the TSI.

Step 1: Defining the Construct

According to Grazioano and Raulin (2000), a construct "is an idea constructed by the researcher to explain events observed in a particular situation. They are explanatory fictions because, in most cases, we do not know the real reason for a particular event. Once formulated, constructs are used as if they are true to predict relationships between variables in situations that had not previously been observed" (p.419). In this study, the researcher proposed to develop an instrument that measures preservice teachers' self-efficacy in regard to the teaching of science through inquiry. Specifically, the two dimensions of self-efficacy to be measured are personal self-efficacy and outcome expectancy as defined by Bandura (1977).

Teaching and learning science as inquiry as recognized by the National Science Education Standards (2000) involves five essential features: (Table 1.1; p.19).

1. Learners are engaged by scientifically oriented questions
2. Learners give priority to evidence which allows them to develop and evaluate explanation that address scientifically oriented questions
3. Learners formulate explanations from evidence to address scientifically oriented questions

4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding
5. Learners communicate and justify their proposed explanations.

Please refer to Table 1.1 (p.19) for further clarification on the variations of each of these essential features. Throughout each stage of the developmental phase of the instrument, the researcher employed the matrix presented in Table 1.1 to ensure that the specific construct of 'inquiry science teaching' was addressed in all instrument items.

Step 2: Version 1 Item Preparation

The first phase involved the development of a preliminary instrument to assess preservice teachers' self-efficacy in regard to inquiry science teaching. To develop this preliminary version of the instrument, the researcher utilized the text, *Inquiry and the National Science Education Standards* (National Research Council, 2000). To devise items representative of the construct to be studied, the researcher first developed version 1 of the TSI (Appendix C). This version of the instrument was composed of a broad set of 31statements to capture the nature of teaching science as inquiry. Although the items represented on Version 1 of the instrument follow the standards set forth by the NSES (2000), they were only a broad set of items that clearly needed to be more thoroughly developed.

Step 3: Content Validity #1

A panel composed of faculty members and graduate students representing the areas of science education and self-efficacy research was identified for the purpose of judging the content validity of Version 1 of the instrument (Appendix D). The panel member's independent feedback was collected and then used as a means to revise the items. Basic grammatical revisions, as well as content revisions were made to the items. Many of the items were revised to become more specific and more clear. The most significant revision made to Version 1 was that several items were added to the instrument. The goal in adding these items was to more thoroughly represent the ideal of teaching science as inquiry. The panel suggested including items that fit into the five following categories:

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

As a result of the activities identified in the first three steps, items from Version 1 were revised. This provided a basis for final item preparation for the next phase of the development process.

Step 4: Content Validity #2

Upon completion of Version 2 of the instrument, a letter that explained the review process and the 81 draft items of Version 2 were submitted to a panel of nine experts consisting of both faculty members as well as graduate students in Science Education at The Pennsylvania State University. Directions, as well as a definition of 'Inquiry,' were provided with the instrument to ensure that all reviewers responded to the instrument in the same manner (Appendix E). The panel reviewed each of the items independently for clarity and comprehension. They were also asked to categorize each of the items into the following five groups, which pertain to the five essential features of classroom inquiry:

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

Comments for improving the items as well as the categorizations were recorded directly on the instrument. Feedback was collected by the researcher and used to revise the items. Information concerning the categorization of each of the items was used to verify if the items represented the intended essential elements. The researcher analyzed the panel's feedback to identify patterns among the data. Items with vast agreement remained on the instrument, whereas items with vast disagreement were revised according to the panel's suggestions or removed from the instrument if suggestions were not provided. Revisions included basic grammatical corrections, as well as content clarification and clarity. In particular, the reviewers suggested revising some of the statements to better represent the five essential elements listed above.

These revised items were then submitted to a panel of faculty members and graduate students for further review. The faculty members and graduate students revised the items until they judged that clarity and comprehension was achieved for each of the items. Ninety-four items were consequently identified for Version 3, within two rounds of review by the faculty members and graduate students (Appendix F).

As a result of the activities identified in step four, items from Version 2 were revised. This provided a basis for final item preparation for the next phase of the development process.

Step 5: Content Validity #3

Using the newly revised version of the instrument, Version 3, another round of construct validity was conducted. The reviewers for this round consisted of only faculty members representing science education and self-efficacy research. These faculty members were given each of the items on the instrument one at a time by the investigator, and were then asked to place each of the items on a larger representation of the matrix illustrated in Table 1.1. (p.19). Throughout this process, the researcher asked the reviewers to verbally convey their thought processes and reasoning behind each of their placements. During this time, the members of the review panel collectively provided feedback to the researcher. To ensure that all feedback would be considered and reflected in the next version of the instrument, the researcher audiotaped this meeting.

Step 6: Revision of Items

As a result of the process discussed in Step 5, Version 3 of the instrument was revised. Most of the revisions consisted of rephrasing the items to better represent the construct of science as inquiry, as well as Bandura's (1977) definition of self-efficacy. Specifically, upon suggestions of the faculty members, the researcher rephrased many of the items to capture the two dimensions of self-efficacy described by Bandura (1977), personal self-efficacy and outcome expectancy. The faculty members also suggested adding seven new items to the instrument in an attempt to better address the definition of self-efficacy, as well as the definition of teaching science as inquiry. Again, during the process of revision, items with vast agreement remained on the instrument whereas items with vast disagreement were either revised or removed from the instrument. In addition, many items were revised for further clarification and clarity.

The activities identified in step five and six provided a basis for final item preparation for the next version of the instrument, Version 4, which consisted of 65 items. Appendix G contains the newly revised items for Version 4.

Step 7: Content Validity #4

Similar to all of the other versions, content validity was conducted on Version 4 of the instrument. Faculty members representing science education and self-efficacy research were constituted for the purpose of judging each of the items representation of the two dimensions of self-efficacy: personal self-efficacy and outcome expectancy (Bandura, 1977). The reviewers analyzed each of the items independently. Similar to previous content review processes, comments from each reviewer regarding improving the items were also recorded directly on the instrument. Feedback was collected by the researcher and used to revise the items. As a result of this review process, it was clear that there were more personal self-efficacy items than outcome expectancy items. Each reviewer offered suggestions pertaining to how several of the items could be transformed from personal self-efficacy to outcome expectancy by simply changing the wording of the item. These comments were used as a means to revise and ensure that there was equal distribution of items within the two dimensions of self-efficacy. In addition, a few of the items were revised for clarity and comprehension.

As a result of the activities identified in Step 7, items from Version 4 were revised. This provided a basis for final item preparation for the next phase of the development process; the creation of Version 5. Appendix H presents a copy of Version 5 of the TSI.

Step 8: Content Validity #5

Version 5 of the instrument also underwent a round of content validity. During this time, faculty members reviewed each of the items to ensure that there was a balance of items within the construct of self-efficacy as defined by Bandura (1977). Specifically, the reviewers viewed each of the items to ensure that there was a relatively equal distribution between the number of items representing personal self-efficacy and the number of items representing outcome expectancy. Each reviewer analyzed the items independently and again made comments directly on the instrument. Basic grammatical revisions, as well as content revisions were made to the items. In addition, revisions were made to enhance the comprehension and clarity of the items.

As a result of the activities identified in Step 8, items from Version 5 were revised. As a result of this round of content validity, revisions were made to Version 5 of the instrument and consequently, Version 6 was created. Version 6 of the TSI can be found in Appendix I.

Step 9: Content Validity #6

Version 6 of the instrument also underwent a round of content validity. During this time, faculty members again reviewed each of the items to ensure that there was a balance of items within the construct of self-efficacy as defined by Bandura (1977). In addition, the reviewers read each of the items to ensure that each clearly illustrated teaching science as inquiry. Specifically, the reviewers again placed each of the items into categories representing the 24 variations of the Essential Elements of Inquiry. Please see Table 1.1. (p.19), Essential Features of Classroom Inquiry and their Variations. Once complete, each of these cells were analyzed to ensure that there was a relatively equal distribution between the number of items representing personal self-efficacy and the number of items representing outcome expectancy within each of the 24 cells. While completing this content validity process, each reviewer analyzed the sixty-five items independently and again made comments directly on the instrument. Basic grammatical revisions, as well as content revisions were made to the items. In additions, revisions were made to enhance the comprehension and clarity of the items.

As a result of this round of content validity, revisions were made to Version 6 of the instrument and consequently, Version 7 was created. A copy of Version 7 of the TSI can be found in Appendix J. Furthermore, Table 3.2 summarizes the results for the item distribution for Version 7 of the instrument. Each cell represents the Essential Features of Classroom Inquiry and Their Variations. The color of each item indicates personal self-efficacy and outcome expectancy.

Table 3.1. Distribution of Items – Version 7

	A	**B**	**C**	**D**
Learner engages in scientifically oriented questions	4, 19, 25	7, 11, 51	37, 38, 48, 66	18, 21, 27, 45, 46
Learner gives priority to evidence in responding to questions	36, 57, 58	5, 13, 17, 30	8, 44, 49, 53	29, 40, 47, 52, 54
Learner formulates explanations from evidence	2, 10, 34, 35, 39	20, 26, 28	1, 31, 55	67, 69
Learner connects explanations to scientific knowledge	3, 15, 61, 63	14, 22, 24	23, 41, 43	XXXXXXXX
Learner communicates and justifies explanations	6, 12, 33	9, 16, 32, 59, 64, 65	50, 60, 62	42, 56, 68

Blue = Personal Self-Efficacy
Personal Self-Efficacy Total = 34

Red = Outcome Expectancy
Outcome Expectancy Total =35

Step 10: Administration of Version 7

Version 7 of the instrument contained 69 items and was administered to the 190 preservice elementary teachers in six sections of SCIED 458: Teaching Science in the Elementary School during the week of September 8, 2003. These groups represented the intended population for the final instrument.

Table 3.2. Demographic Data for Version 7

SCIED 458 Section	Male	Female	Total
0	2	40	42
1	4	26	30
2	2	29	31
3	0	28	28
4	8	22	30
5	2	27	29
TOTAL	**18**	**172**	**190**
Percentage	**9.47%**	**90.53%**	**100%**

Step 11: Analysis of Data #1 (September, 2003)

The data obtained from administering the 69-item Version 7 to the SCIED 458 classes were used to identify the items to be included in the TSI. The following guiding question was developed for this purpose:

> What is the most reliable and valid combination of items to compose the TSI for the purposes of assessing preservice elementary teaches self-efficacy beliefs in regard to teaching science as inquiry, and the two dimensions of self-efficacy; personal self efficacy and outcome expectancy?

This question required the researcher to use data from Version 7 to examine the construct validity of the items and the contributions each item made to the reliability of the instrument. Hence, data from the Version 7 items were examined for evidence of construct validity. Item score to total test score correlation and item contribution to total test reliability were used to identify the "strongest" items and therefore eliminate those that were not positively contributing to the overall reliability of the instrument. Item balance across the 24 variations of the Essential Elements of Classroom Inquiry was also examined to determine the reliability of the instrument. Coefficient Alpha, a measure of internal consistency, was utilized to examine the reliability of score for the instrument. The strongest combination of construct valid and reliable items that had balanced representation within the Table 1.1 The Essential Features of Classroom Inquiry and Their Variations, were identified using these procedures in combination. The ranges on the internal consistency were from a .4906 to a .7429. These ranges meet and/or exceed the requirements set forth by Sax (1974) and Nunnally (1978) pertaining to first generation instrument construction. Outcome expectancy for the category "Learner Connects Explanations to Scientific Knowledge" of the instrument, produced the lowest alpha, an alpha of .4906. Although this Alpha is not as high as one would desire, omitting any item from this category would only lower the reliability of the instrument. In addition one factor that contributes to the reliability of a test is the number of items on the test (Anastasi & Urbina, 1997). For this particular analysis there were only four items in the category resulting in the .4906 Alpha. The small amount of items within this category could have possibly accounted for the low reliability in this particular instance.

The data obtained during these analyses were used to arrange items for Version 8 of the TSI. Version 8 is presented in Appendix K. Due to the reliability results for the internal consistency, as well as the correlation data, Version 8 of the TSI consisted of the identical items that were present of Version 7. Revisions made to Version 7 were aesthetic in nature and were therefore done to enhance the readability and visual appearance of the instrument. In addition, these revisions may also contribute to the ease at which participants complete the instrument. Font size was enlarged to increase the participants ease in reading the items, sentence starters were added to reduce redundancy while reading the items, and shading was added to every other item to provide more ease when completing the instrument. Details on the entire analysis process are addressed in Chapter 4.

Step 12: Administration of Version 8

A second construct validity and reliability study was conducted on the TSI Version 8 during the week of December 1, 2003 (Appendix K). This was done to further develop evidence of the instrument's construct validity and to collect data on the internal reliability and test-retest reliability of the instrument. Version 8 of the instrument contained 69 items and was administered to the 184 preservice elementary teachers in six sections of SCIED 458: Teaching Science in the Elementary School during the week of December 1, 2003. These groups again represented the intended population for the final instrument. The resulting data were used in formulating the TSI as described in Step 13, below.

Table 3.3. Demographic Data for Version 8

SCIED 458 Section	Male	Female	Total
0	2	36	38
1	4	26	30
2	2	27	29
3	0	27	27
4	9	22	31
5	2	27	29
TOTAL	**19**	**165**	**184**
Percentage	**10.33%**	**89.67%**	**100%**

Step 13: Analysis of Data #2

Data obtained from the administration of the 69-item Version 8 of the TSI to the SCIED 458 classes were used to identify items to be included in the final version of the instrument. Similar to Step 11, again the researcher examined the construct validity of the items and the contributions each item made to the reliability of the instrument. Data from Version 8 of the instrument were examined for evidence of construct validity. Item score to total test score correlation and item contribution to total test reliability were used. Item balance across the 24 variations of the Essential Elements of Classroom Inquiry was also examined to determine the reliability of the instrument. Coefficient Alpha, a measure of internal consistency, was utilized as a means to examine the reliability of the instrument. The strongest combination of construct valid and reliable items that had balanced representation within Table 1.1 The Essential Features of Classroom Inquiry and Their Variations, were identified using these procedures in combination. The ranges on the internal consistency were from .5036 to .8373. These ranges again meet and/or exceed the requirements set forth by Sax (1974) and Nunnally (1978) pertaining to first generation instrument construction. In addition, most of these results meet more strict standards set forth by Anastasi & Urbina (1997), Isaac & Michael (1997) and Roden (2000).

One-way ANOVA scores on the TSI were compared across the six sections of SCIED 458. The .05 level for statistical significance was used to determine if statistically significant differences in the sub-scale scores existed on the TSI among the six sections. Please refer to Appendix L and Appendix M for further information regarding the ANOVA scores.

Test-retest reliability was also calculated on the TSI to determine the external consistency of the instrument. The scores on these two tests were correlated (Pearson's correlation) to determine the reliability of scores. For the purposes of this study, a single group, test-retest method was used. Details on these analyses are provided in Chapter 4.

Data obtained during these analyses indicate that this pool of items best represents the intended means of the instrument. Due to the reliability results as determined by the internal consistency, as well as the correlation data, the final version of the TSI consisted of the identical items that were present on Version 8 (Appendix N). No further revisions were made for the purposes of this research.

Chapter 4

Data Analysis and Results

This chapter presents details on the data analysis associated with the development of the TSI as described in Chapter 3. Specifically, details and results are given on the data analysis associated with Step 11: Analysis of Data #1, Step 12: Administration of Version 8, and Step 13: Analysis of Data #2.

Analysis of Data Results

Version 7 of the TSI consisted of 69 items that had been judged to be content valid for the purposes of assessing prospective elementary teachers self-efficacy beliefs with regard to the teaching of science as inquiry. The goals of Step 11 (See Chapter 3) were to identify instrument items that: a) were construct valid, b) had acceptable internal consistency reliability, and c) were representative of the content matrix presented in Table 1.1. Coefficient alpha reliability, a measure of internal consistency, was used to examine the internal consistency of the groups of items.

Data for these analyses for the pre-test were collected by administering the 69 item “Version 7” instrument to the prospective elementary teachers in the Pennsylvania State University Elementary/Kindergarten Education (EK ED) program. These included the students in the six sections of SCIED 458: Teaching Science in the Elementary School. Usable data were secured from 190 of these prospective elementary teachers. The mean self-efficacy score on the pre-test among the 190 prospective elementary teachers was 3.77 with a standard deviation of .39 (theoretical score range was 1 through

5). The mean outcome expectancy score on the pre-test for the same group of participants was 3.59 with a standard deviation of .37 (theoretical score range was 1 through 5).

Data analyses for the post-test were collected by administering the 69 item Version 8 instrument to the prospective elementary teachers in the Pennsylvania State University Elementary/Kindergarten Education (EKED) program. These included the students in the six sections of SCIED 458: Teaching Science in the Elementary School. Usable data were secured from 184 of these prospective elementary teachers. The mean self-efficacy score on the post-test among the 184 prospective elementary teachers was 3.99 with a standard deviation of .37 (theoretical score range was 1 through 5). The mean outcome expectancy score on the post test among the 184 participants was 3.85 with a standard deviation of .40 (theoretical score range was again 1 through 5). The data analyses are described below. (Table 4.1 through 4.8)

Table 4.1. Reliability Results For Male And Female: Self-Efficacy For The Essential Elements Of Inquiry-Version 7

Essential Element	Male	Female
Learner Engages in Scientifically Oriented Questions	n = 17 Items = 7 alpha = .6269 Item Mean = 3.84 Item s = .34	n = 168 Items = 7 alpha = .6931 Item Mean = 3.68 Item s = .18
Learner Gives Priority to Evidence in Responding to Questions	n = 18 Items = 8 alpha = .6754 Item Mean = 3.67 Item s = .27	n = 169 Items = 8 alpha = .6223 Item Mean = 3.49 Item s = .27
Learner Formulates Explanations from Evidence	n = 17 Items = 6 alpha = .3590 Item Mean = 4.01 Item s = .06	n = 168 Items = 6 alpha = .6348 Item Mean = 3.84 Item s = .04
Learner Connects Explanations to Scientific Knowledge	n = 18 Items = 6 alpha = .5502 Item Mean = 3.94 Item s = .06	n = 169 Items = 6 alpha = .7562 Item Mean = 3.88 Item s = .04
Learner Communicates and Justifies Explanations	n = 18 Items = 7 alpha =. 6341 Item Mean = 3.97 Item s = .04	n = 169 Items = 7 alpha = .7362 Item Mean = 4.00 Item s = .02

Reliability Analysis – Scale Cronbach Alpha

Table 4.2. Reliability Results For Section Male And Female: Self-Efficacy For The Essential Elements Of Inquiry-Version 8

Essential Element	**Male**	**Female**
Learner Engages in Scientifically Oriented Questions	n = 19 Items = 7 alpha = .4747 Item Mean = 3.95 Item s = .10	n = 165 Items = 7 alpha = .6737 Item Mean = 3.95 Item s = ..07
Learner Gives Priority to Evidence in Responding to Questions	n = 19 Items = 8 alpha = .5740 Item Mean = 3.88 Item s = .21	n = 162 Items = 8 alpha = .6668 Item Mean = 3.78 Item s = .29
Learner Formulates Explanations from Evidence	n = 19 Items = 6 alpha = .6487 Item Mean = 4.02 Item s = .04	n = 164 Items = 6 alpha = .6789 Item Mean = 4.05 Item s = .03
Learner Connects Explanations to Scientific Knowledge	n = 19 Items = 6 alpha = .7979 Item Mean = 3.99 Item s = .03	n = 164 Items = 6 alpha = .7520 Item Mean = 4.08 Item s = .003
Learner Communicates and Justifies Explanations	n = 19 Items = 7 alpha = .8302 Item Mean = 4.07 Item s = .04	n = 164 Items = 7 alpha = .7382 Item Mean = 4.17 Item s = .01

Reliability Analysis – Scale Cronbach Alpha

Table 4.3. Reliability Results For Male And Female: Outcome Expectancy For The Essential Elements Of Inquiry-Version-7

Essential Element	**Male**	**Female**
Learner Engages in Scientifically Oriented Questions	n = 18 Items = 8 alpha =.8232 Item Mean = 3.58 Item s = .05	n = 168 Items = 8 alpha =.7079 Item Mean = 3.49 Item s = .13
Learner Gives Priority to Evidence in Responding to Questions	n = 18 Items = 8 alpha =.7103 Item Mean = 3.63 Item s = .37	n = 170 Items = 8 alpha =.6467 Item Mean = 3.49 Item s = .48
Learner Formulates Explanations from Evidence	n = 18 Items = 7 alpha =.0572 Item Mean = 3.83 Item s = .28	n = 171 Items = 7 alpha =.6642 Item Mean = 3.71 Item s = .16
Learner Connects Explanations to Scientific Knowledge	n = 18 Items = 4 alpha =.2647 Item Mean = 3.74 Item s = .27	n = 171 Items = 4 alpha =.5068 Item Mean = 3.87 Item s = .12
Learner Communicates and Justifies Explanations	n = 18 Items = 8 alpha =.1816 Item Mean = 3.39 Item s = .19	n = 167 Items = 8 alpha =.6079 Item Mean = 3.57 Item s = .18

Reliability Analysis – Scale Cronbach Alpha

Table 4.4. Reliability Results For Male And Female: Outcome Expectancy For The Essential Elements Of Inquiry-Version-8

Essential Element	**Male**	**Female**
Learner Engages in Scientifically Oriented Questions	n = 19 Items = 8 alpha = .5755 Item Mean = 3.78 Item s = .10	n = 163 Items = 8 alpha = .7986 Item Mean = 3.74 Item s = .16
Learner Gives Priority to Evidence in Responding to Questions	n = 19 Items = 8 alpha = .7188 Item Mean = 3.86 Item s = .22	n = 162 Items = 8 alpha = .6994 Item Mean = 3.71 Item s = .30
Learner Formulates Explanations from Evidence	n = 18 Items = 7 alpha = .6060 Item Mean = 3.93 Item s = .08	n = 161 Items = 7 alpha =.6772 Item Mean = 3.98 Item s = .15
Learner Connects Explanations to Scientific Knowledge	n = 19 Items = 4 alpha = .4862 Item Mean = 4.17 Item s = .05	n = 164 Items = 4 alpha = .6130 Item Mean = 4.06 Item s = .04
Learner Communicates and Justifies Explanations	n = 19 Items = 8 alpha = .6199 Item Mean = 3.97 Item s = .13	n = 162 Items = 8 alpha = .6843 Item Mean = 3.80 Item s = .20

Reliability Analysis – Scale Cronbach Alpha

Table 4.5. Reliability Results For Section 0 – 5: Self-Efficacy For The Essential Elements Of Inquiry-Version 7

Essential Elements	Section 0	Section 1	Section 2	Section 3	Section 4	Section 5
Learner Engages in Scientifically Oriented Questions	n = 42 Items = 7 alpha = .6345 Item Mean = 3.60 Item s = .21	n = 27 Items = 7 alpha = .7326 Item Mean = 3.83 Item s = .10	n = 30 Items = 7 alpha = .7374 Item Mean = 3.41 Item s = .23	n = 28 Items = 7 alpha = .6569 Item Mean = 3.67 Item s = .09	n = 30 Items = 7 alpha = .4454 Item Mean = 3.96 Item s = .40	n = 28 Items = 7 alpha = .7086 Item Mean = 3.74 Item s = .29
Learner Gives Priority to Evidence in Responding to Questions	n = 40 Items = 8 alpha = .6309 Item Mean = 3.36 Item s = .31	n = 30 Items = 8 alpha = .6624 Item Mean = 3.66 Item s = .20	n = 31 Items = 8 alpha = .6870 Item Mean = 3.28 Item s = .25	n = 27 Items = 8 alpha = .5288 Item Mean = 3.53 Item s = .19	n = 30 Items = 8 alpha = .4742 Item Mean = 3.70 Item s = .36	n = 29 Items = 8 alpha = .5154 Item Mean = 3.59 Item s = .40
Learner Formulates Explanations from Evidence	n = 40 Items = .07 alpha = .5522 Item Mean = 3.85 Item s = .07	n = 29 Items = 6 alpha = .6652 Item Mean = 3.86 Item s = .04	n = 31 Items = 6 alpha = .6073 Item Mean = 3.62 Item s = .04	n = 26 Items = 6 alpha = .5857 Item Mean = 3.72 Item s = .03	n = 30 Items = 6 alpha = .6089 Item Mean = 4.03 Item s = .08	n = 29 Items = 6 alpha = .4810 Item Mean = 4.04 Item s = .11
Learner Connects Explanations to Scientific Knowledge	n = 41 Items = 6 alpha = .7798 Item Mean = 3.89 Item s = .03	n = 30 Items = 6 alpha = .6411 Item Mean = 3.97 Item s = .05	n = 30 Items = 6 alpha = .7133 Item Mean = 3.63 Item s = .05	n = 27 Items = 6 alpha = .7767 Item Mean = 3.74 Item s = .03	n = 30 Items = 6 alpha = .7250 Item Mean = 4.18 Item s = .07	n = 29 Items = 6 alpha = .5440 Item Mean = 3.87 Item s = .07
Learner Communicates and Justifies Explanations	n = 41 Items = 7 alpha = .7743 Item Mean = 3.93 Item s = .07	n = 30 Items = 7 alpha = .8019 Item Mean = 4.05 Item s = .02	n = 30 Items = 7 alpha = .7044 Item Mean = 3.82 Item s = .02	n = 27 Items = 7 alpha = .5610 Item Mean = 3.94 Item s = .03	n = 30 Items = 7 alpha = .7168 Item Mean = 4.17 Item s = .02	n = 29 Items = 7 alpha = .6056 Item Mean = 4.11 Item s = .06

Reliability Analysis – Scale Cronbach Alpha

Table 4.6. Reliability Results For Section 0 – 5: Self-Efficacy For The Essential Elements Of Inquiry-Version 8

Essential Elements	**Section 0**	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
Learner Engages in Scientifically Oriented Questions	n = 38 Items = 7 alpha = .5978 Item Mean = 3.94 Items s = .10	n = 30 Items = 7 alpha = .7407 Item Mean = 3.96 Items s = .07	n = 29 Items = 7 alpha = .6039 Item Mean = 4.03 Items s = .13	n = 27 Items = 7 alpha = .7337 Item Mean = 3.89 Items s = .06	n = 31 Items = 7 alpha = .6216 Item Mean = 3.92 Items s = .08	n = 29 Items = 7 alpha = .6820 Item Mean = 3.98 Items s = .06
Learner Gives Priority to Evidence in Responding to Questions	n = 36 Items = 8 alpha = .6966 Item Mean = 3.70 Items s = .48	n = 30 Items = 8 alpha = .5036 Item Mean = 3.89 Items s = .10	n = 29 Items = 8 alpha = .7097 Item Mean = 3.79 Items s = .34	n = 27 Items = 8 alpha = .5432 Item Mean = 3.73 Items s = .29	n = 30 Items = 8 alpha =.6737 Item Mean = 3.82 Items s = .25	n = 29 Items = 8 alpha = .7347 Item Mean = 3.84 Items s = .30
Learner Formulates Explanations from Evidence	n = 38 Items = 6 alpha = .6702 Item Mean = 4.08 Items s = .08	n = 30 Items = 6 alpha = .6889 Item Mean = 3.97 Items s = .03	n = 29 Items = 6 alpha = .6564 Item Mean = 4.05 Items s = .08	n = 27 Items = 6 alpha = .6603 Item Mean = 4.09 Items s = .02	n = 31 Items = 6 alpha = .6972 Item Mean = 3.90 Items s = .03	n = 28 Items = 6 alpha = .6677 Item Mean = 4.19 Items s = .01
Learner Connects Explanations to Scientific Knowledge	n = 38 Items = 6 alpha = .7306 Item Mean = 4.12 Items s = .01	n = 30 Items = 6 alpha = .8373 Item Mean = 4.03 Items s = .02	n = 28 Items = 6 alpha = .7657 Item Mean = 4.18 Items s = .02	n = 27 Items = 6 alpha = .6561 Item Mean = 4.06 Items s = .01	n = 31 Items = 6 alpha = .7453 Item Mean = 3.98 Items s = .01	n = 29 Items = 6 alpha =.7844 Item Mean = 4.05 Items s = .01
Learner Communicates and Justifies Explanations	n = 38 Items = 7 alpha = .6660 Item Mean = 4.21 Items s = .05	n = 30 Items = 7 alpha = .8210 Item Mean = 4.03 Items s = .02	n = 28 Items = 7 alpha = .7786 Item Mean = 4.27 Items s = .003	n = 27 Items = 7 alpha = .6921 Item Mean = 4.20 Items s = .03	n = 31 Items = 7 alpha = .7476 Item Mean = 4.02 Items s = .04	n = 29 Items = 7 alpha = .7953 Item Mean = 4.22 Items s = .01
Reliability Analysis – Scale Cronbach Alpha						

Table 4.7. Reliability Results For Section 0 – 5: Outcome Expectancy For The Essential Elements Of Inquiry-Version 7

Essential Elements	Section 0	Section 1	Section 2	Section 3	Section 4	Section 5
Learner Engages in Scientifically Oriented Questions	n = 41 Items = 8 alpha = .6751 Item Mean = 3.34 Item s = .14	n = 29 Items = 8 alpha = .7966 Item Mean = 3.62 Item s = .13	n = 30 Items = 8 alpha = .6986 Item Mean = 3.32 Item s = .16	n = 27 Items = 8 alpha = .5560 Item Mean = 3.74 Item s = .07	n = 30 Items = 8 alpha = .7427 Item Mean = 3.47 Item s = .11	n = 29 Items = 8 alpha = .7006 Item Mean = 3.58 Item s = .19
Learner Gives Priority to Evidence in Responding to Questions	n = 42 Items = 8 alpha = .6204 Item Mean = 3.33 Item s = .66	n = 30 Items = 8 alpha = .6703 Item Mean = 3.64 Item s = .29	n = 30 Items = 8 alpha = .7541 Item Mean = 3.35 Item s = .40	n = 27 Items = 8 alpha = .5243 Item Mean = 3.67 Item s = .31	n = 30 Items = 8 alpha = .6365 Item Mean = 3.56 Item s = .68	n = 29 Items = 8 alpha = .5839 Item Mean = 3.58 Item s = .56
Learner Formulates Explanations from Evidence	n = 42 Items = 7 alpha = .5057 Item Mean = 3.63 Item s = .22	n = 30 Items = 7 alpha = .7728 Item Mean = 3.75 Item s = .09	n = 31 Items = 7 alpha = .7391 Item Mean = 3.50 Item s = .14	n = 27 Items = 7 alpha = .5287 Item Mean = 3.74 Item s = .07	n = 30 Items = 7 alpha = .4318 Item Mean = 3.94 Item s = .31	n = 29 Items = 7 alpha = .3827 Item Mean = 3.83 Item s = .27
Learner Connects Explanations to Scientific Knowledge	n = 42 Items = 4 alpha = .1604 Item Mean = 3.72 Item s = .11	n = 30 Items = 4 alpha = .5954 Item Mean = 3.93 Item s = .10	n = 31 Items = 4 alpha = .4141 Item Mean = 3.67 Item s = .25	n = 27 Items = 4 alpha = .6371 Item Mean = 3.79 Item s = .11	n = 30 Items = 4 alpha = .5839 Item Mean = 4.11 Item s = .15	n = 29 Items = 4 alpha = .3025 Item Mean = 4.01 Item s = .17
Learner Communicates and Justifies Explanations	n = 41 Items = 8 alpha = .6320 Item Mean = 3.48 Item s = .20	n = 28 Items = 8 alpha = .1853 Item Mean = 3.61 Item s = .20	n = 31 Items = 8 alpha = .5632 Item Mean = 3.40 Item s = .21	n = 27 Items = 8 alpha = .7567 Item Mean = 3.61 Item s = .17	n = 29 Items = 8 alpha = .6459 Item Mean = 3.63 Item s = .19	n = 29 Items = 8 alpha = .3918 Item Mean = 3.62 Item s = .20
Reliability Analysis – Scale Cronbach Alpha						

Table 4.8. Reliability Results For Section 0 – 5: Outcome Expectancy For The Essential Elements Of Inquiry-Version 8

Essential Elements	Section 0	Section 1	Section 2	Section 3	Section 4	Section 5
Learner Engages in Scientifically Oriented Questions	n = 36 Items = 8 alpha = .7948 Item Mean = 3.63 Item s = .16	n = 30 Items = 8 alpha = .7144 Item Mean = 3.88 Items s = .10	n = 29 Items = 8 alpha =.8309 Item Mean = 3.63 Items s = .22	n = 27 Items = 8 alpha = .8254 Item Mean = 3.89 Items s = .14	n = 31 Items = 8 alpha = .7851 Item Mean = 3.71 Items s = .20	n = 29 Items = 8 alpha = .6931 Item Mean = 3.77 Items s = .20
Learner Gives Priority to Evidence in Responding to Questions	n = 38 Items = 8 alpha = .7382 Item Mean = 3.61 Items s = .53	n = 30 Items = 8 alpha =.6298 Item Mean = 3.86 Items s = .17	n = 29 Items = 8 alpha = .7631 Item Mean = 3.63 Items s = .42	n = 27 Items = 8 alpha = .6442 Item Mean = 3.68 Items s = .24	n = 30 Items = 8 alpha = .7326 Item Mean = 3.79 Items s = .22	n = 27 Items = 8 alpha = .5950 Item Mean = 3.83 Items s = .21
Learner Formulates Explanations from Evidence	n = 37 Items = 7 alpha = .5958 Item Mean = 3.98 Items s = .29	n = 30 Items = 7 alpha = .7088 Item Mean = 3.40 Items s = .11	n = 28 Items = 7 alpha = .8233 Item Mean = 3.93 Items s = .21	n = 27 Items = 7 alpha = .6512 Item Mean = 3.89 Items s = .15	n = 30 Items = 7 alpha = .6187 Item Mean = 3.93 Items s = .13	n = 27 Items = 7 alpha = .5562 Item Mean = 4.10 Items s = .09
Learner Connects Explanations to Scientific Knowledge	n = 37 Items = 4 alpha = .5647 Item Mean = 4.01 Items s = .14	n = 30 Items = 4 alpha = .5786 Item Mean = 4.02 Items s = .02	n = 29 Items = 4 alpha = .7267 Item Mean = 4.10 Items s = .04	n = 27 Items = 4 alpha = .6142 Item Mean = 4.13 Items s = .01	n = 31 Items = 4 alpha = .5681 Item Mean = 4.16 Items s = .09	n = 29 Items = 4 alpha = .6122 Item Mean = 4.04 Items s = .04
Learner Communicates and Justifies Explanations	n = 38 Items = 8 alpha = .6200 Item Mean = 3.70 Items s = .37	n = 30 Items = 8 alpha = .6874 Item Mean = 3.90 Items s = .11	n = 29 Items = 8 alpha = .7997 Item Mean = 3.80 Items s = .26	n = 26 Items = 8 alpha = .7000 Item Mean = 3.82 Items s = .16	n = 31 Items = 8 alpha = .6815 Item Mean = 3.83 Items s = .16	n = 27 Items = 8 alpha = .5560 Item Mean = 3.86 Items s = .19

Reliability Analysis – Scale Cronbach Alpha

Item Reliability Results

The contribution each of the 69 items made to total instrument scores and reliability also was examined for to determine the possible composition of the instrument from a reliability perspective. All 69 items were judged to be appropriate for inclusion in the instrument based on this perspective. That is, each of the 69 items had the highest item to total instrument score correlations generated by the Coefficient alpha reliability for the total instrument and two subscales. Item Contribution to 69-item Version 7 TSI presents the item means, item variances, item to total scale correlations and reliability results (Tables 4.9 through 4.28). From a reliability prospective, the instrument would include 69 items.

Table 4.9. Reliability Results for Self-Efficacy: Learner Engages in Scientifically Oriented Questions – Version 7

	Mean	Std Dev	Cases
1. Q4	3.8865	.8029	185.0
2. Q19	3.9514	.8228	185.0
3. Q11	4.1784	.7339	185.0
4. Q37	3.8162	.8067	185.0
5. Q38	3.848	.7582	185.0
6. Q18	2.9784	.8658	185.0
7. Q21	3.1838	.8715	185.0
N of Cases = 185.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
25.8432	11.2090	3.3480	7

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.6919	2.9784	4.1784	1.2000	1.4029	.1915

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q4	21.9568	9.2481	.2695	.1398	.6874
Q19	21.8919	8.5535	.4111	.2294	.6503
Q11	21.6649	8.5066	.5054	.2773	.6278
Q37	22.0270	8.4069	.4599	.2992	.6370
Q38	21.9946	8.4837	.4869	.3098	.6314
Q18	22.8649	8.5849	.3695	.2183	.6625
Q21	22.6595	8.8562	.3072	.1952	.6803

Reliability Coefficients 7 items	
Alpha = .6884	Standardized item alpha = .6939

Table 4.10. Reliability Results for Self-Efficacy: Learner Engages in Scientifically Oriented Questions – Version 8

	Mean	**Std Dev**	**Cases**
1. Q4	4.0163	.6651	184.0
2. Q19	3.9620	.7119	184.0
3. Q11	4.3152	.5616	184.0
4. Q37	4.0435	.7077	184.0
5. Q38	4.1141	.7190	184.0
6. Q18	3.4891	.8683	184.0
7. Q21	3.7228	.9376	184.0
N of Cases = 184.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
27.6630	8.9787	2.9965	7

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.9519	3.4891	4.3152	.8261	1.236	.0729

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q4	23.6467	7.6942	.2282	.0752	.6584
Q19	23.7011	7.4785	.2552	.1195	.6531
Q11	23.3478	7.4193	.4066	.2108	.6178
Q37	23.6196	6.8599	.4364	.2227	.6027
Q38	23.5489	6.6861	.4775	.2746	.5901
Q18	24.1739	6.3958	.4164	.2779	.6069
Q21	23.9402	6.2751	.3884	.2463	.6194

Reliability Coefficients 7 items	
Alpha = .6579	Standardized item alpha = .6643

Table 4.11. Reliability Results for Self-Efficacy: Learner Gives Priority to Evidence in Responding to Questions – Version 7

	Mean	**Std Dev**	**Cases**
1. Q36	3.8930	.8609	187.0
2. Q5	3.3636	.7872	187.0
3. Q17	3.8824	.7311	187.0
4. Q30	4.0642	.6769	187.0
5. Q44	3.6524	.8811	187.0
6. Q49	3.4439	.8236	187.0
7. Q40	3.3636	.8838	187.0
8. Q54	2.4118	1.0299	187.0
N of Cases = 187.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
28.0749	12.6288	3.5537	8

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.5094	2.4118	4.0642	1.6524	1.6851	.2666

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q36	24.1818	10.7840	.1952	.1712	.6356
Q5	24.7112	10.8624	.2210	.1021	.6264
Q17	24.1925	10.5111	.3340	.1726	.5989
Q30	24.0107	10.4623	.3901	.2412	.5877
Q44	24.4225	9.0625	.5259	.3306	.5393
Q49	24.6310	9.6212	.4559	.2916	.5638
Q40	24.7112	9.9269	.3449	.2164	.5944
Q54	25.6631	10.1923	.2092	.1358	.6413

Reliability Coefficients 8 items	
Alpha = .6315	Standardized item alpha = .6427

Table 4.12. Reliability Results for Self-Efficacy: Learner Gives Priority to Evidence in Responding to Questions – Version 8

	Mean	**Std Dev**	**Cases**
1. Q36	4.0387	.7772	181.0
2. Q5	3.7735	.6486	181.0
3. Q17	4.0718	.6149	181.0
4. Q30	4.3039	.6337	181.0
5. Q44	3.8508	.8399	181.0
6. Q49	3.7348	.8733	181.0
7. Q40	3.9890	.8755	181.0
8. Q54	2.5746	1.1211	181.0
N of Cases = 181.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
30.3370	12.4913	3.5343	8

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.7921	2.5746	4.3039	1.7293	1.6717	2756

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	
Q36	26.2983	10.5549	.2638	.1451	.6481
Q5	26.5635	11.0140	.2455	.1018	.6503
Q17	26.2652	11.2293	.2145	.1197	.6557
Q30	26.0331	10.5656	.3700	.2389	.6262
Q44	26.4862	9.0512	.5411	.3840	.5750
Q49	26.6022	8.7298	.5811	.4540	.5608
Q40	26.3481	10.2726	.2588	.1238	.6523
Q54	27.7624	8.8266	.3615	.2613	.6328

Reliability Coefficients 8 items	
Alpha = .6583	Standardized item alpha = .6598

Table 4.13. Reliability Results for Self-Efficacy: Learner Formulates Explanations from Evidence – Version 7

	Mean	**Std Dev**	**Cases**
1. Q2	3.9838	.6467	185.0
2. Q10	3.9946	.7482	185.0
3. Q26	3.5514	.7214	185.0
4. Q1	3.8216	.6304	185.0
5. Q31	4.0595	.7084	185.0
6. Q67	3.6973	.8567	185.0
N of Cases = 185.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
23.1081	6.4665	2.5429	6

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.8514	3.5514	4.0595	5081	1.1431	.0392

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q2	19.1243	4.8921	.4042	.2638	.5567
Q10	19.1135	5.1664	.2177	.0772	.6277
Q26	19.5568	4.8459	.3464	.1742	.5765
Q1	19.2865	4.8251	.4492	.2811	.5417
Q31	19.0486	4.5031	.4861	.2529	.5200
Q67	19.4108	4.7651	.2587	.1056	.6210

Reliability Coefficients 6 items	
Alpha = .6189	Standardized item alpha = .6337

Table 4.14. Reliability Results for Self-Efficacy: Learner Formulates Explanations from Evidence – Version 8

	Mean	**Std Dev**	**Cases**
1. Q2	4.0328	.6454	183.0
2. Q10	4.0601	.6967	183.0
3. Q26	4.0820	.6703	183.0
4. Q1	3.8962	.5977	183.0
5. Q31	4.3333	.6319	183.0
6. Q67	3.8689	.8983	183.0
N of Cases = 183.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
24.2732	6.6612	2.5809	6

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
4.0455	3.8689	4.3333	.4645	1.1201	.0276

Item Means					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q2	20.2404	4.8540	.4891	.3985	.6067
Q10	20.2131	4.6741	.4985	.2654	.6003
Q26	20.1913	5.0127	.3996	.2020	.6352
Q1	20.3770	5.0384	.4716	.3459	.6155
Q31	19.9399	5.0678	.4197	.2247	.6296
Q67	20.4044	4.9125	.2365	.0947	.7137

Reliability Coefficients 6 items	
Alpha = .6749	Standardized item alpha = .6962

Table 4.15. Reliability Analysis for Self-Efficacy: Learner Connects Explanations to Scientific Knowledge – Version 7

	Mean	**Std Dev**	**Cases**
1. Q3	4.2513	.6358	187.0
2. Q63	3.7861	.6857	187.0
3. Q14	3.9198	.6792	187.0
4. Q22	3.8128	.7636	187.0
5. Q23	3.6364	.7157	187.0
6. Q43	3.8877	.6981	187.0
N of Cases = 187.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
23.2941	7.6603	2.7677	6

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.8824	3.6364	4.2513	.6150	1.1691	.0424

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q3	19.0428	5.9551	.4192	.1829	.7223
Q63	19.5080	5.9072	.3850	.1633	.7320
Q14	19.3743	5.6441	.4819	.2388	.7059
Q22	19.4813	5.3263	.4968	.2672	.7020
Q23	19.6578	5.3231	.5526	.3229	.6850
Q43	19.4064	5.4038	.5451	.3121	.6877

Reliability Coefficients 6 items	
Alpha = .7429	Standardized item alpha = .7421

Table 4.16. Reliability Results for Self-Efficacy: Learner Connects Explanations to Scientific Knowledge – Version 8

	Mean	**Std Dev**	**Cases**
1. Q3	4.1749	.6647	183.0
2. Q63	4.0601	.6726	183.0
3. Q14	4.0984	.6963	183.0
4. Q22	4.0000	.6112	183.0
5. Q23	4.0000	.7032	183.0
6. Q43	4.0929	.6851	183.0
N of Cases = 183.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
24.4262	7.3778	2.7162	6

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
4.0710	4.0000	4.1749	.1749	1.0437	.0044

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q3	20.2514	5.6727	.3990	.2078	.7488
Q63	20.3661	5.2334	.5498	.3263	.7092
Q14	20.3279	5.4633	.4392	.2117	.7394
Q22	20.4262	5.3558	.5826	.3647	.7032
Q23	20.4262	5.2239	.5162	.3124	.7183
Q43	20.3333	5.2784	.5178	.2897	.7179

Reliability Coefficients 6 items	
Alpha = .7582	Standardized item alpha = .7600

Table 4.17. Reliability Analysis for Self-Efficacy: Learner Communicates and Justifies Explanations – Version 7

	Mean	**Std Dev**	**Cases**
1. Q12	4.2406	.7039	187.0
2. Q33	3.8824	.7311	187.0
3. Q16	4.1016	.8068	187.0
4. Q32	3.8396	.7448	187.0
5. Q65	3.9893	.7258	187.0
6. Q62	4.0856	.7355	187.0
7. Q42	3.8610	.8437	187.0
N of Cases = 187.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
28.0000	10.5914	3.2544	7

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
4.0000	3.8396	4.2406	.4011	1.1045	.0224

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q12	23.7594	8.0977	.4987	.3083	.6784
Q33	24.1176	8.1474	.4575	.2293	.6873
Q16	23.8984	8.1563	.3872	.2089	.7050
Q32	24.1604	8.4795	.3590	.1466	.7103
Q65	24.0107	8.2579	.4331	.2404	.6931
Q62	23.9144	8.0464	.4802	.2940	.6819
Q42	24.1390	7.7870	.4444	.2243	.6909

Reliability Coefficients 7 items	
Alpha = .7244	Standardized item alpha = .7267

Table 4.18. Reliability Results for Self-Efficacy: Learner Communicates and Justifies Explanations – Version 8

	Mean	Std Dev	Cases
1. Q12	4.3825	.5986	183.0
2. Q33	4.1311	.6413	183.0
3. Q16	4.1257	.7342	183.0
4. Q32	4.0765	.7447	183.0
5. Q65	4.0546	.7392	183.0
6. Q62	4.1913	.6966	183.0
7. Q42	4.1366	.7397	183.0
N of Cases = 183.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
29.0984	9.7925	3.1293	7

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
4.1569	4.0546	4.3825	.3279	1.0809	.0118

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q12	24.7158	8.0617	.4037	.1856	.7410
Q33	24.9672	7.4934	.5377	.3203	.7146
Q16	24.9727	7.7520	.3672	.2767	.7506
Q32	25.0219	7.3841	.4580	.2353	.7307
Q65	25.0437	7.0860	.5489	.3313	.7096
Q62	24.9071	7.1177	.5891	.3957	.7015
Q42	24.9617	7.5095	.4282	.3442	.7374

Reliability Coefficients 7 items	
Alpha = .7566	Standardized item alpha = .7584

Table 4.19. Reliability Results for Outcome Expectancy: Learner Engages in Scientifically Oriented Questions – Version 7

	Mean	**Std Dev**	**Cases**
1. Q25	4.1183	.8034	186.0
2. Q7	3.0430	.7838	186.0
3. Q51	3.6559	.9808	186.0
4. Q48	3.7043	.7452	186.0
5. Q66	3.5753	.8619	186.0
6. Q27	3.2151	.9625	186.0
7. Q45	3.3710	.9737	186.0
8. Q46	3.2796	.8806	186.0
N of Cases = 186.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
27.9624	16.9121	4.1124	8

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.4953	3.0430	4.1183	1.0753	1.3534	.1156

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q25	23.8441	14.9431	.2131	.0602	.7353
Q7	24.9194	13.9989	.3919	.1721	.7036
Q51	24.3065	13.5110	.3383	.1279	.7169
Q48	24.2581	13.9979	.4230	.2497	.6987
Q66	24.3871	14.1737	.3075	.1742	.7199
Q27	24.7473	11.9953	.5985	.4668	.6567
Q45	24.5914	11.8970	.6055	.4850	.6546
Q46	24.6828	13.1259	.4718	.2929	.6872

Reliability Coefficients 8 items	
Alpha = .7259	Standardized item alpha = .7218

Table 4.20. Reliability Results for Outcome Expectancy: Learner Engages in Scientifically Oriented Questions – Version 8

	Mean	Std Dev	Cases
1. Q25	4.5330	.6619	182.0
2. Q7	3.3462	.8383	182.0
3. Q51	3.6648	.8295	182.0
4. Q48	3.9780	.7577	182.0
5. Q66	3.6923	.8101	182.0
6. Q27	3.7033	1.0191	182.0
7. Q45	3.7308	1.0132	182.0
8. Q46	3.3187	.9563	182.0
N of Cases = 182.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
29.9670	19.1923	4.3809	8

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.7459	3.3187	4.5330	1.2143	1.3659	.1467

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q25	25.4341	17.6503	.1985	.0860	.7965
Q7	26.6209	15.8831	.3901	.2056	.7747
Q51	26.3022	15.9468	.3860	.2374	.7752
Q48	25.9890	15.5689	.5100	.3382	.7572
Q66	26.2747	15.9352	.4022	.1960	.7726
Q27	26.2637	13.1234	.6813	.6160	.7221
Q45	26.2363	13.2091	.6730	.6418	.7240
Q46	26.6484	13.8757	.6179	.4698	.7358

Reliability Coefficients 8 items	
Alpha = .7833	Standardized item alpha = .7708

Table 4.21. Reliability Results for Outcome Expectancy: Learner Gives Priority to Evidence in Responding to Questions – Version 7

	Mean	**Std Dev**	**Cases**
1. Q57	4.0319	.6367	188.0
2. Q58	4.1755	.6671	188.0
3. Q13	3.8404	.8248	188.0
4. Q8	4.4362	.6385	188.0
5. Q53	2.9202	.9186	188.0
6. Q29	2.8936	.9475	188.0
7. Q47	3.0053	.9393	188.0
8. Q52	2.7500	.7918	188.0
N of Cases = 188.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
28.0532	12.2004	3.4929	8

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.5066	2.7500	4.4362	1.6862	1.6132	.4632

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q57	24.0213	11.2723	.1223	.1942	.6715
Q58	23.8777	11.6160	.0307	.1762	.6902
Q13	24.2128	9.4411	.4102	.2510	.6095
Q8	23.6170	11.0397	.1775	.1148	.6614
Q53	25.1330	8.7148	.4871	.3800	.5849
Q29	25.1596	8.6589	.4741	.3381	.5884
Q47	25.0479	8.4095	.5339	.4189	.5692
Q52	25.3032	9.2391	.4849	.4141	.5906

Reliability Coefficients 8 items	
Alpha = .6568	Standardized item alpha = .6264

Table 4.22. Reliability Results for Outcome Expectancy: Learner Gives Priority to Evidence in Responding to Questions – Version 8

	Mean	**Std Dev**	**Cases**
1. Q57	4.0608	.7239	181.0
2. Q58	4.0829	.6902	181.0
3. Q13	4.2873	.6793	181.0
4. Q8	4.4365	.5702	181.0
5. Q53	3.3536	.9757	181.0
6. Q29	3.1547	.9240	181.0
7. Q47	3.2818	1.0452	181.0
8. Q52	3.1657	.8914	181.0
N of Cases = 181.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
29.8232	14.2241	3.7715	8

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.7279	3.1547	4.4365	1.2818	1.4063	.2908

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q57	25.7624	12.5599	.2222	.1534	.7063
Q58	25.7403	13.6489	.0194	.1088	.7390
Q13	25.5359	12.4168	.2811	.1874	.6951
Q8	25.3867	13.1829	.1729	.1106	.7105
Q53	26.4696	9.4282	.6415	.5348	.6064
Q29	26.6685	10.3895	.5005	.2851	.6472
Q47	26.5414	9.1386	.6319	.5230	.6066
Q52	26.6575	10.0598	.5959	.5110	.6233

Reliability Coefficients 8 items	
Alpha = .7026	Standardized item alpha = .6662

Table 4.23. Reliability Results for Outcome Expectancy: Learner Formulates Explanations from Evidence – Version 7

	Mean	**Std Dev**	**Cases**
1. Q34	3.7831	.7583	189.0
2. Q35	4.1852	.7598	189.0
3. Q39	4.2063	.6801	189.0
4. Q20	3.7513	.7625	189.0
5. Q28	3.4074	.8043	189.0
6. Q55	3.0635	.7829	189.0
7. Q69	3.6614	.8640	189.0
N of Cases = 189.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
26.0582	9.1508	3.0250	7

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.7226	3.0635	4.2063	1.1429	1.3731	.1650

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q34	22.2751	6.9239	.4139	.3613	.5713
Q35	21.8730	7.0902	.3666	.3351	.5864
Q39	21.8519	7.0311	.4595	.3674	.5617
Q20	22.3069	7.0223	.3828	.1605	.5812
Q28	22.6508	7.2178	.2976	.1775	.6089
Q55	22.9947	7.7393	.1833	.1078	.6434
Q69	22.3968	6.9321	.3236	.1357	.6017

Reliability Coefficients 7 items	
Alpha = .6309	Standardized item alpha = .6375

Table 4.24. Reliability Results for Outcome Expectancy: Learner Formulates Explanations from Evidence – Version 8

	Mean	**Std Dev**	**Cases**
1. Q34	4.0782	.8035	179.0
2. Q35	4.1564	.7096	179.0
3. Q39	4.5084	.5937	179.0
4. Q20	4.0112	.7343	179.0
5. Q28	3.9888	.8413	179.0
6. Q55	3.2737	.8466	179.0
7. Q69	3.7877	.9419	179.0
N of Cases = 179.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
27.8045	10.2256	3.1977	7

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.9721	3.2737	4.5084	1.2346	1.3771	.1427

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q34	23.7263	7.8853	.3756	.3845	.6359
Q35	23.6480	8.3080	.3457	.3472	.6441
Q39	23.2961	8.4343	.4173	.2810	.6309
Q20	23.7933	7.8166	.4554	.2549	.6146
Q28	23.8156	7.4433	.4519	.2661	.6124
Q55	24.5307	7.8572	.3480	.2524	.6447
Q69	24.0168	7.7357	.3059	.2165	.6625

Reliability Coefficients 7 items	
Alpha = .6701	Standardized item alpha = .6814

Table 4.25. Reliability Results for Outcome Expectancy: Learner Connects Explanations to Scientific Knowledge

	Mean	Std Dev	Cases
1. Q15	3.8360	.8377	189.0
2. Q61	4.3651	.7064	189.0
3. Q24	3.6243	.7083	189.0
4. Q41	3.6138	.7608	189.0
N of Cases = 189.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
15.4392	3.6093	1.8998	4

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.8598	3.6138	4.3651	.7513	1.2079	.1240

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q15	11.6032	2.1662	.3007	.0947	.4063
Q61	11.0741	2.4519	.2976	.0900	.4097
Q24	11.8148	2.5347	.2540	.0666	.4470
Q41	11.8254	2.3470	.2933	.0863	.4120

Reliability Coefficients 4 items	
Alpha = .4906	Standardized item alpha = .4913

Table 4.26. Reliability Results for Outcome Expectancy: Learner Connects Explanations to Scientific Knowledge – Version 8

	Mean	**Std Dev**	**Cases**
1. Q15	3.9945	.7667	183.0
2. Q61	4.3661	.7205	183.0
3. Q24	3.8852	.7935	183.0
4. Q41	4.0492	.7208	183.0
N of Cases = 183.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
16.2951	4.1212	2.0301	4

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
4.0738	3.8852	4.3661	.4809	1.1238	.0426

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q15	12.3005	2.5410	.4059	.1827	.5152
Q61	11.9290	2.8246	.3211	.1071	.5775
Q24	12.4098	2.3201	.4846	.2403	.4484
Q41	12.2459	2.8128	.3263	.1168	.5739

Reliability Coefficients 4 items	
Alpha = .6034	Standardized item alpha = .6002

Table 4.27. Reliability Analysis for Outcome Expectancy: Learner Communicates and Justifies Explanations – Version 7

	Mean	Std Dev	Cases
1. Q6	4.1243	.7737	185.0
2. Q9	3.1243	.9839	185.0
3. Q59	3.9676	.7438	185.0
4. Q64	3.6378	.8746	185.0
5. Q50	3.5676	.8190	185.0
6. Q60	3.6432	.7606	185.0
7. Q56	2.8000	.8956	185.0
8. Q68	3.5405	.8532	185.0
N of Cases = 185.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
28.4054	11.5358	3.3964	8

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.5507	2.8000	4.1243	1.3243	1.4730	.1807

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q6	24.2811	10.0075	.1899	.1298	.5761
Q9	25.2811	9.7793	.1281	.1265	.6064
Q59	24.4378	9.2583	.3809	.2246	.5226
Q64	24.7676	9.0598	.3250	.1738	.5358
Q50	24.8378	9.1801	.3396	.1919	.5320
Q60	24.7622	9.0844	.4085	.2335	.5135
Q56	25.6054	9.1967	.2829	.1589	.5499
Q68	24.8649	9.3132	.2870	.2238	.5483

Reliability Coefficients 8 items	
Alpha = .5817	Standardized item alpha = .5936

Table 4.28. Reliability Results for Outcome Expectancy: Learner Communicates and Justifies Explanations – Version 8

	Mean	**Std Dev**	**Cases**
1. Q6	4.4475	.6269	181.0
2. Q9	3.4862	.9866	181.0
3. Q59	4.1050	.7416	181.0
4. Q64	3.8122	.8152	181.0
5. Q50	3.9724	.8461	181.0
6. Q60	3.9558	.7876	181.0
7. Q56	2.9779	.9187	181.0
8. Q68	3.7569	.8004	181.0
N of Cases = 181.0			

Statistics for Scale			
Mean	**Variance**	**Std Dev**	**N of Variables**
30.5138	13.3401	3.6524	8

Item Means					
Mean	**Minimum**	**Maximum**	**Range**	**Max/Min**	**Variance**
3.8142	2.9779	4.4475	1.4696	1.4935	.1916

Item-total Statistics					
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Squared Multiple Correlation**	**Alpha if Item Deleted**
Q6	26.0663	12.2734	.1534	.1102	.6906
Q9	27.0276	10.6492	.2667	.0934	.6815
Q59	26.4088	10.6097	.4513	.3253	.6332
Q64	26.7017	10.4216	.4282	.3113	.6364
Q50	26.5414	10.1608	.4567	.3223	.6286
Q60	26.5580	10.0480	.5351	.4141	.6115
Q56	27.5359	10.9056	.2621	.2686	.6791
Q68	26.7569	10.3739	.4511	.2661	.6312

Reliability Coefficients 8 items	
Alpha = .6801	Standardized item alpha = .6839

Coefficient Alpha Reliability Results for Self-Efficacy

Coefficient alpha was used to assess the reliability of the 69-item TSI and its sub-scales using data secured from the prospective elementary teachers from the EK ED program. Of the five essential elements, the results for both the pretest and post-test administration are presented in Tables 4.9 through 4.18. In regard to self-efficacy, the results reveal that two of the five elements exceed a Cronbach's alpha of .7 (Issac & Michael, 1996) on both the pre-test and the post-test. These two elements were "Learner Connects Explanations to Scientific Knowledge" {alpha = .74 for pre-test (Table 4.15) and .76 for post test (Table 4.16)} and "Learner Communicates and Justifies Explanations" {alpha = .72 for pre-test (Table 4.17) and .76 for post-test (Table 4.18)}.

Some researchers (Sax, 1974; Nunnally, 1978) suggest that for first generation instruments, the standard of alpha = .7 or higher should be relaxed to .6. In this study, all three of the remaining elements had Cronbach alpha levels of .6 or higher for both the pre- and post-test. The results for the remaining three elements were:

1. Learner Engages in Scientifically Oriented Questions {alpha = .69 for the pre-test (Table 4.9) and .66 for the post-test (Table 4.10}
2. Learner Gives Priority to Evidence in Responding to Questions {alpha = .63 for the pre-test (Table 4.11) and .66 for the post-test (Table 4.12)}
3. Learner Formulates Explanations from Evidence {alpha = .62 for the pre-test (Table 4.13) and .67 for the post-test (Table 4.14)}

Coefficient Alpha Reliability Results for Outcome Expectancy

Coefficient alpha was again used to assess the reliability of the 69-item TSI and its sub-scales using data secured from the prospective elementary teachers from the EK ED program. Of the five essential elements, the results for both the pretest and post test administration are presented in Tables 4.19 through 4.28. For Outcome Expectancy, the results reveal that one of the five essential elements exceeds a Cronbach's alpha of .7 (Issac & Michael, 1996) on both the pre-test and the post-test. The results also reveal that a second essential elements exceeds this standard on the post-test only. These elements were "Learner Engages in Scientifically Oriented Questions Knowledge" {alpha = .73 for pre-test (Table 4.19) and .78 for post test (Table 4.20)}. and Learner Gives Priority to Evidence in Responding to Questions" {alpha = .70 for post-test (Table 4.22)}.

Some researchers (Sax, 1974; Nunnally, 1978) suggest that for first generation instruments, the standard of alpha = .7 or higher should be relaxed to .6. In this study, all three of the remaining elements had Cronbach alpha levels of .6 or higher for both the pre- and post-test. The results for the remaining three elements were:

1. Learner Gives Priority to Evidence in Responding to Questions {alpha = .66 on the pre-test (Table 4.21) and .70 on the post-test (Table 4.22}
2. Learner Formulates Explanations from Evidence {alpha = .63 on the pre-test (Table 4.23) and .67 on the post-test (Table 4.24)}
3. Learner Connects Explanations to Scientific Knowledge {alpha = .49 on the pre-test (Table 4.25) and .60 on the post-test (Table 4.26)}
4. Learner Communicates and Justifies Explanations {alpha = .58 on the pre-test (Table 4.27) and .68 on the post-test (Table 4.28)}

Consistency in Subscale Scores Across Gender and Across Section

The investigator also examined scale subscore difference of both the self-efficacy and outcome expectancy scales by gender of the respondents and section of the courses to assess whether there were differences across these factors. Appendix O provides reliability information pertaining to gender, and Appendix P provides reliability information pertaining to section.

Chapter 5

Summary, Conclusion, Implications, and Recommendations

Summary

Currently, inquiry is a major theme within the context of educational reform. In December 1995, the National Research Council (NRC) released the National Science Education Standards (NSES), which indicate "a vision of science education that will make scientific literacy for all a reality in the 21st century" (p. ix). Subsequently, in 1996 the National Research Council released the *National Science Education Standards* (NSES). Within these standards, scientific inquiry is seen as an integral component for restructuring science education. Scientific inquiry involves a rich learning environment, with a focus on inquiry-based learning, which creates opportunities for children to internalize or transform new information, which in turn allows students to create and expand their individual cognitive structures (Lee & Krapfl, 2002). Inquiry learning fosters greater conceptual understanding rather than rote learning of science concepts and facts (Lee & Krapfl, 2002).

Based on the concepts of social learning theory (Bandura, 1977), if inquiry is to be successfully integrated in our elementary science classrooms, preservice teachers should first be provided with opportunities to understand and experience success with science instruction. They must experience first-hand how inquiry science takes place within an elementary school setting. As substantiated by social learning theory, if preservice teachers experience success within a science methods course, they are more likely to model effective inquiry instruction within their own elementary science classrooms, which should in turn promote their students' scientific literacy. Thus it is important for elementary teachers to understand inquiry and be able to teach science through inquiry. Teachers' beliefs appear to be good indicators of future instructional behaviors (Ashton & Web, 1986a, 1986b; Bandura, 1986; Riggs, 1988; Riggs & Enochs, 1990). Teacher efficacy beliefs have been found to be valid predictors of practicing and prospective elementary teaches' behaviors in regard to the teaching and learning of science (Ashton & Web, 1986a, 1986b; Bandura, 1986; Riggs, 1988; Riggs & Enochs, 1990). This current study builds upon the work of Aston and Webb (1986a, 1986b), Bandura (1977, 1986), Riggs (1988), and Riggs and Enochs (1990) with application to preservice elementary teachers' beliefs concerning the teaching of science as inquiry.

Study Purpose

The purpose of this study was to develop and validate an instrument to assess the self-efficacy beliefs of prospective elementary teachers with regard to the teaching of science as inquiry (TSI). This developmental study focused on the initial stages of instrument validation and assessment of internal consistency or reliability. This study is significant for several reasons. First, the study fills a void in the literature and contributes to furthering our understanding of prospective elementary teachers' self-efficacy in regard to the teaching of science as inquiry. Second, the study extends the self-efficacy theory base to the teaching of science as inquiry and the preservice elementary teachers' self-efficacy beliefs. Finally, the instrument provides an additional approach for assessing active reform efforts. More specifically, educational reform as it relates to the preparations and professional development of science teachers and the teaching of science at the local school level.

Methodology

A thirteen-step instrument development approach was utilized to develop the instrument. The researcher first defined the construct to be measured; self-efficacy. Once the construct was defined, thirty-one initial draft, Likert-type response scale items were prepared. These items were modeled after the STEBI B (Enochs & Riggs, 1990). Subsequently, these thirty-one draft, self-efficacy items were reviewed by science education instructors at the Pennsylvania State University. The reviewers were instructed to examine each of the items relative to understanding, clarification and content validity relative to the self-efficacy construct. Feedback from these reviewers was collected and examined by the researcher. Subsequently, items were revised and/or omitted from the instrument to enhance clarity and comprehension.

Using the revised instrument, the researcher then assembled a panel of faculty members representing science education. These faculty members assessed the content validity of the revised items. The items were then revised again based on feedback from the faculty members. Following this revision, Version 7 of the revised instrument was administered during the week of September 8, 2003 to approximately 200 prospective elementary teachers in six sections of SCIED 458 – Teaching of Science in the Elementary School. This group of participants represented the intended population for the final instrument. The Version 7 instrument, which contained 69 Likert type response scale items, modeled after those composing the STEBI A (Riggs, 1988) and the STEBI B (Enochs & Riggs, 1990) included at least one self-efficacy and outcome expectancy item for each cell of the Essential Elements of Inquiry and the Variations matrix (National Research Council, 2000).

Data from the 200 preservice teachers was analyzed using item analysis procedures to identify the contribution of each item to the relative subscale score. As part of the item analysis procedures, internal consistency measures were calculated.

In the next step, the information obtained from administering Version 7 of the TSI to the SCIED 458 classes was used to develop Version 8 of the instrument. Version 8 was administered to the same group of preservice elementary teachers during the week of December 1, 2003. Although the actual basic content of the first draft was not changed as a result of data analysis, many aesthetic revisions were made to enhance the ease with which a participant completed the instrument. For example, a larger size font was chosen, and every other item on the instrument was shaded to assist the participant with readability.

Conclusion

Based on the instrument development processes used and the associated data analysis results, the TSI appears to be a content and construct valid instrument with high/moderate internal reliability and high/moderate test-retest reliability qualities for use with preservice elementary education teachers to assess self-efficacy in regard to the teaching of science as inquiry. Instrument reliability results are summarized in Tables 5.1 through 5.2. The Cronbach alpha internal consistency data reveal an acceptable level of reliability in the scores for first generation instruments (Sax, 1974; Nunnally, 1978).

Table 5 1. Reliability Results For Self-Efficacy And Outcome Expectancy For The Essential Elements Of Inquiry-Version 7

Essential Element	**Self-Efficacy**	**Outcome Expectancy**
Learner Engages in Scientifically Oriented Questions	n = 185 Items = 7 alpha = .6884 Item Mean = 3.69 Item s = .19	n = 186 Items = 8 alpha = .7259 Item Mean = 3.50 Item s = .12
Learner Gives Priority to Evidence in Responding to Questions	n = 187 Items = 8 alpha = .6315 Item Mean = 3.51 Item s = .27	n = 188 Items = 8 alpha = .6568 Item Mean = 3.51 Item s = .46
Learner Formulates Explanations from Evidence	n = 185 Items = 6 alpha = .6189 Item Mean = 3.85 Item s = .04	n = 189 Items = 7 alpha = .6309 Item Mean = 3.72 Item s = .17
Learner Connects Explanations to Scientific Knowledge	n = 187 Items = 6 alpha = .7429 Item Mean = 3.89 Item s = .04	n = 189 Items = 4 alpha = .4906 Item Mean = 3.86 Item s = .12
Learner Communicates and Justifies Explanations	n = 187 Items = 7 alpha = .7244 Item Mean = 4.0 Item s =. 02	n = 185 Items = 8 alpha = .5817 Item Mean = 3.56 Item s = .18

Reliability Analysis – Scale Cronbach Alpha

Table 5.2. Reliability Results For Self-Efficacy And Outcome Expectancy For The Essential Elements Of Inquiry-Version 8

Essential Element	**Self-Efficacy**	**Outcome Expectancy**
Learner Engages in Scientifically Oriented Questions	n = 184 Items = 7 alpha = .6579 Item Mean = 3.95 Item s = .07	n = 182 Items = 8 alpha = .7833 Item Mean = 3.75 Item s = .15
Learner Gives Priority to Evidence in Responding to Questions	n = 181 Items = 8 alpha = .6583 Item Mean = 3.79 Item s = .28	n = 181 Items = 8 alpha = .7026 Item Mean = 3.73 Item s = .29
Learner Formulates Explanations from Evidence	n = 183 Items = 6 alpha = .6749 Item Mean = 4.05 Item s = .03	n = 179 Items = 7 alpha = .6701 Item Mean = 3.97 Item s = .14
Learner Connects Explanations to Scientific Knowledge	n = 183 Items = 6 alpha =.7582 Item Mean = 4.07 Item s = .004	n = 183 Items = 4 alpha = .6034 Item Mean = 4.07 Item s = .04
Learner Communicates and Justifies Explanations	n = 183 Items = 7 alpha = .7566 Item Mean = 4.16 Item s = .01	n = 181 Items = 8 alpha = .6801 Item Mean = 3.81 Item s = .19

Reliability Analysis – Scale Cronbach Alpha

Implications

Based on the study results, the experiences of the investigator and prior literature, three areas of implications are specifically addressed; implications for research, policy and practice.

Research Implications

The construct validity of an instrument is never fully established or achieved (Nunnally, 1970), thus it is important to continue examining the construct validity of the TSI. In the process, the reliability of the instrument, including test-retest reliability should continue to be assessed.

There are several research implications targeted toward teacher efficacy and science education. Research is needed to further explore the effects of self-efficacy on teacher development and how self-efficacy may affect eventual classroom practice. The TSI is a valuable tool for science teacher educators working in practical and research settings to assess the self-efficacy beliefs of prospective elementary teachers with regard to the teaching of science as inquiry.

The TSI should be used in combination with other data collection techniques to more fully determine the self-efficacy beliefs of prospective teachers. These data collection techniques may include but are not limited to observations of teachers engaged in the teaching of science as inquiry as well as interviews with prospective teachers to more clearly understand their ideas and beliefs associated with the teaching of science as inquiry. Although quantitative and qualitative research methods have been regarded as being "fundamentally different modes of inquiry," both can be pursued rigorously

(Shavelson, 2002, p.19). Shavelson (2002) notes that the current trend of research in education to greater use of qualitative methods at the expense of quantitative methods has created a dialogue of criticism. The nation's commitment to make "…scientific literacy for all a reality in the 21st century" requires continued efforts to improve the research capacity of science education (National Research Council 1996, p.ix; Shavelson, 2002). What makes research scientific is not the motive for carrying it out, but the manner in which it is carried out" (2002, p.20). Hence, using a mixed methods approach to investigate preservice teacher self-efficacy should assist in achieving this goal.

Observation of preservice teachers in the classroom could provide additional information in relation to the predictive validity of the instrument. By observing classroom teaching, one would be able to determine if a particular score on the instrument transferred into behavior and practice. Additionally, development of a form of the TSI for practicing elementary teachers should be pursued as was done with the STEBI B. Furthermore, using the information obtained from both versions of this instrument as well as classroom observations and/or interviews, comparisons can be made between the scores of preservice and inservice elementary science teachers.

In addition, because the instrument utilized a force choice response from the prospective elementary teacher, interviews should also be conducted. These interviews may more fully explore the prospective elementary teachers thoughts associated with the items on the TSI, as well as their responses to these items. This interview process could indicate if the preserviece teacher truly understood the meaning of the items and if the researcher thoroughly understood the prospective elementary teachers responses to the items. The inclusion of interviews would allow for a deeper understanding of the preservice teachers' self-efficacy in regard to the teaching of science as inquiry.

The idea of preservice elementary teachers' self-reporting inflated self-efficacy perceptions with regard to the teaching of science as inquiry also needs to be investigated. Because this study relied on self-report data, it would behoove researchers to further investigate the idea of social desirability bias (SDB) (Nancarrow & Brace, 2000; Ray, 1990). SDB refers to the possibility of respondents reporting what they perceive is socially desirable rather than what might be the actual case. Researchers such as Phillips and Clancy (1972) believe that SDB occurs because of two factors: the general strength of need for approval felt by an individual (personality trait) and the demands of a particular situation (as cited in Nancarrow & Brace, 2000). Another important factor that may contribute to SDB is the desire to present oneself in a favorable light to others and or a self-esteem preservation function (2000; 1990). Although these are possible concerns, there are many ways in which researchers may reduce this problem. For example, a Likert-type scale, similar to the one used for the TSI, is one viable solution to the problem of SDB (Ray, 1990).

Another area warranting further consideration is the concept of types of teacher efficacy. Although research has indicated that positive teacher efficacy is an appropriate goal (Bandura, 1977, 1985, 1986; Ashton, 1985; Ashton & Webb, 1982; 1986; Tschannen-Moran & Woolfolk Hoy, 2001), Wheatley (2000; 2002) has identified eight different types of positive teacher efficacy that he considers problematic. These eight types of positive teacher efficacy that are considered problematic are as follows: traditional methods, traditional goals, too-certain efficacy, overly-optimistic novices, hypothetical future efficacy, pretend teacher efficacy, competitive teacher efficacy, and independent teacher control (2000).

Traditional methods and traditional goals efficacy relate to efficacy that is grounded in traditional teaching approaches (Wheatley 2000). Many teachers derive their sense of efficacy from the use of traditional teaching practices. Therefore, when implementing reform minded approaches, a teachers' sense of efficacy can become threatened. For example, when implementing reformed teaching, a teacher who may have positive self-efficacy in the area of traditional methods may anticipate a short-term decline in teaching effectiveness if new methods are attempted. This likely will result in a decline in self-perceived effectiveness during early implementation of these methods (2000). This anticipation of decreased efficacy is a disincentive for adopting new methods as well as persisting with these reform methods. Furthermore, it provides an incentive for returning to traditional methods of teaching (2000).

Too-certain efficacy, overly-optimistic novices, hypothetical future efficacy, and pretend teacher efficacy are four types of inappropriately grounded positive teacher efficacy. Each of these four types of efficacy provide the illusion of true teacher efficacy; however, each creates difficulties for professional development and educational reform.

Too-certain efficacy refers to teachers who seem to negate the complexities of teaching. Teachers with this type of efficacy reflect the belief that they have teaching "all figured out" (Wheatley, 2000, p.19). Unfortunately, this type of attitude diminishes the goals of reformed teaching. This naivety may provide comfort and satisfaction; however, it also provides an incentive for resisting the disequilibrium and ongoing change associated with reformed teaching (2000).

Overly-optimistic novices is another problematic type of positive teacher efficacy. This type of efficacy refers specifically to beginning teachers or teachers new to reform whose optimism is not yet grounded in practice (Wheatley, 2000). Although at times, optimism may be helpful, too much optimism about reform may create substantial disillusionment. This disillusionment in turn may decrease the likelihood that reformed teaching practices will be sustained (2000).

Hypothetical future efficacy exists for teachers whose positive efficacy is rooted in a hypothetical future rather than in actual classroom success (Wheatley, 2000). This type of efficacy refers to teachers who may have experienced reformed teaching, and they believe that it can have an effect on students. The problem however is that these teachers believe that these effects can only be achieved if certain things could change (2000).

Pretend teacher efficacy is another problematic situation where teachers pretend to have a positive sense of efficacy that they do not necessarily feel (Wheatley, 2000). Oftentimes, this can be referred to as social desirability bias and can occur if teacher efficacy is a high stakes issue. Pretend efficacy is problematic not only because it hides a teacher's uncertainty and failure, but also it makes the difficult task of reform even more complex.

Competitive teacher efficacy and independent teacher control refer to teacher efficacy grounded in individual accomplishments (Wheatley, 2000). Competitive teacher efficacy addresses the competitive desire to be the most effective teacher. Because reform efforts emphasize collaboration as a means for improving teaching and learning, positive teacher efficacy may undermine reform if it reflects a valued sense of superiority to other teachers (2000).

Teacher efficacy often emphasizes the teacher's ability to 'get through to' students, which Wheatley, (2002) also refers to as independent teacher control. However, teaching in "reform minded" ways often requires a teacher to step aside rather than exert control over students, in an attempt to enhance or promote student learning. Clearly, this conflict between strong teacher control which is inherent in the traditional conceptions of teaching, and the student-directed and hands-on learning emphasized by reformers, creates a dilemma when attempting to measure efficacy. Using more reformed teaching practices can oftentimes create uncertainty in one's own teaching. For example, teachers using a more reform oriented approach may take less credit for their influence on student outcomes than teachers using a more traditional approach (2000).

The foundation for Wheatley's (2000; 2002) research is the belief that teachers' doubts about their teaching efficacy often have important benefits for teacher learning and educational reform (2000; 2002). Wheatley believes that these "doubts are essential to widespread success of educational reform, particularly for reforms that promote progressive meaning-centered education" (2002, p.5). Although these assertions conflict with most of the previous research on teacher efficacy, it is important to carefully explore the meaning of these findings as well as their relationship to educational reform. Thus, in order to more fully understand and encourage the types of teacher efficacy that support teacher development, new approaches to teacher efficacy research are needed. In order to identify how teacher efficacy, confidence and doubt may work together, research should be conducted within the context of the daily realities of teaching (Wheatley, 2002). Additionally, these new approaches for investigating teacher efficacy should include qualitative means of research.

Another critical research question that needs to be examined is the relationship between self-efficacy and teaching as inquiry on student outcomes in science classes. This research can be done in the context of a modified framework proposed by Duncan and Biddle (1974) or Cruickshank (1985). Duncan and Biddle (1974) suggest a model for classroom teaching and learning that is useful for understanding the many variables that must be addressed by teachers in an attempt to assist student learning. Within this model, Duncan and Biddle (1974) propose four major types of variables that influence student learning: presage variables, context variables, process variables, and product variables. Presage variables are variables associated with the teacher and therefore, affect the behavior of the teacher in the classroom. Within presage variables, self-efficacy should be included. Context variables are those that are not totally in the control of the teacher. These variables are attributed to the students, the school, and the community. Process variables refer to what takes place in the classroom between teacher and pupil. Such variable may include interactions between teacher behavior and pupil behavior resulting in observable changes in pupil behavior.

The model by Cruickshank (1985) is more classroom- and teacher-based and was influenced by the work of Duncan and Biddle (1974). More specifically, the relationship found by Duncan and Biddle (1974) between specific learning activities and teacher effects provides the foundation for Cruickshank's model. Cruickshank's model centers around four types of variables: presage variables, context variables, process variables, and product variables. Presage variables relate to teacher formative experiences, teacher training experiences, and teacher properties. Context variables include pupil formative experiences, pupil properties, school and community contexts, and classroom contexts.

Process variables refer to the interactions taking place within the classroom setting and the resulting changes in pupil behavior. Product variables consist of immediate pupil growth and long-term pupil effects.

Models such as these have been used in educational psychology to further investigate student learning. When used in the context of a modified framework which includes self-efficacy as a variable, research could examine more completely the relationship between teacher self-efficacy and student learning.

Policy and Practice

The TSI is a useful tool for the evaluation of science method courses with an emphasis on inquiry teaching. Although research and evaluation are two separate entities, through the use of the aforementioned research techniques and methods, program improvement, development, and assessment should be facilitated.

"Like other research, evaluation attempts to describe, to understand the relationships between variables, and to trace out the causal sequence" (Weiss, 1972, p.8). Evaluation applies the methods of social research and is distinguished by its intent, the purpose for which it is done, rather than the method or subject matter, which refers to research. The purpose of evaluation research is to measure the effects of a program against the goals it set out to accomplish (1972; Payne, 1994). For example, test-retest data derived from the TSI instrument can be used in combination with other research techniques using an experimental model. This evaluation can help to identify if a particular course is achieving what it purports with regard to the teaching of science as inquiry. The data derived from this analysis is then used to make decisions about the program and/or future programs.

When analyzing this data however, it is important for researchers to realize that reliability values may decrease from pre-test to post-test. This in fact was evident in the reliability results presented in Table 5.1 and 5.2. The scores reported for "Learner Engages in Scientifically Oriented Questions" in relation to Self-Efficacy decreased from an alpha of .6884 on the pre-test to an alpha of .6579 on the post-test. It is the researchers conjecture that when students initially entered the science methods course, their conceptions associated with "Learner Engages in Scientifically Oriented Questions" were different than what is actually involved in the teaching of science as inquiry. Teaching science as inquiry requires teachers to possess a "sophisticated set of judgments about science, students, learning, and teaching" (National Research Council, 1996, p.37). The central strategy for teaching science as inquiry is to use authentic questions generated from students' experiences. Teachers provide students with the opportunity to investigate these questions by giving students investigations or by guiding students toward designing investigations of their own. As a result, "teachers of science are constantly making decisions, such as when to change the direction of a discussion, how to engage a particular student, when to let a student pursue a particular interest, and how to use an opportunity to model scientific skills and attitudes" (1996, p.33). Consequently, this complex decision making process requires teachers to struggle with the tension between guiding students toward a set of predetermined goals and allowing students to set and meet their own goals (1996). Thus, when preservice teachers have the opportunity to experience a science methods course that provides preservice teachers the opportunity to experience the teaching of science as inquiry, their previously held conceptions may change. These preservice teachers may come to realize that the teaching of science as inquiry is much more complex and more difficult than they had originally thought.

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Appendix A

Curriculum & Instruction SCIED 458 Prerequisite Courses

The science courses listed below may be used to fulfill the **3 credits each** of biological, earth, and physical sciences required as prerequisites to SCIED 458 in the Elementary and Kindergarten Teacher Education (EK ED) major. STUDENTS MUST SELECT ONE COURSE FROM EACH COLUMN.

PLEASE NOTE:

- It is highly recommended that one of the three science courses be a laboratory course. Laboratory courses are indicated by an asterisk on this list.
- All courses are 3 credits unless otherwise indicated.
- GEOG 10(GN), GEOG 110(GN), and GEOG 115(GN) do not count for the EK ED Geography requirement.
- For ENT 313/315, ENGR 497F, and MICRB 297F, students must have these courses approved via ACADEMIC PETITION.

BIOLOGICAL	EARTH	PHYSICAL
AGESS 121	AAA S (EARTH) 105	AERSP (STS) 55
AN SC 300	AGESS 121	ASTRO 1
ANTH 21	AGESS (PL SC) 134	ASTRO 10(2)
BMB 1	AERSP (STS) 55	*ASTRO 11(1)
BI SC 1	ASRTO 1	ASTRO 120
BI SC 2	ASTRO 10(2)	ASTRO 140
BI SC 3	*ASTRO 11(1)	ASTRO 230
BI SC 4	ASTRO 120	ASTRO 291
*BIOL 11(3) / BIOL 12(1)	ASTRO 140	ASTRO 292
BIOL 20	ASTRO 230	CHEM 1
BIOL 27	ASTRO 291	CHEM 2
BIOL 33	ASTRO 292	*CHEM 12(3) / CHEM 14(1)
BIOL 55	BI SC 3	*CHEM 13(3) / CHEM 15(1
*BIOL 110(4)	ERM 210	*CHEM 17(5) / CHEM 14(1)
BIOL 129	EARTH 2	EGEE (MATSC) 101
BIOL 141	EARTH 100	*ENGR 497F - must petition
*BIOL 220W(4)	EARTH 101	MATSC 81
*BIOL 220W(4)	EARTH 103	MATSC (EGEE) 101
*BIOL 230W(4)	EARTH (AAA S) 105	PHYS 1

*BIOL 240W(4)	EGEE (MATSC) 101	PHYS 150
BIOL 341	EGEE 102	PHYS 151
ENT 202	EM SC 121	*PHYS 201(4) or PHYS 211(4)
*ENT 313/315 - must petition	EM SC (STS) 150	*PHYS 202(4) or PHYS 212(4)
MICRB 106	*GEOG 10	PHYS 203
*MICRB 107(1)	GEOG 110	*PHYS 204(4) OR
*MICRB 297F at Altoona - must petition	GEOG 115	PHYS 213(2) AND PHYS 214(2)
WFS 209	*GEOSC 2	PHYS 215(4)
□	GEOSC 10	□PHYS 250(4)
	□*GEOSC 20	PHYS 251(4)
	□GEOSC 21	PHYS 255
	□*GEOSC 40	*PHYS 265(4)
	□GEOSC 109H	STS (AERSP) 55
□	□GEOSC 110H	
□	□HORT 101	
□	□*METEO 2(3)	
□	□*METEO 3	□
□	□METEO 101	□
	□PL SC (AGES) 134	□
□	□STS (AERSP) 55	
	STS (EM SC) 150	
	STS 201	

Source: http://www.ed.psu.edu/edservices/certification/ent_criteria.html and http://www.ed.psu.edu/pds.

Appendix B

INFORMED CONSENT FOR BEHAVIORAL RESEARCH STUDY

The Pennsylvania State University

Title of project: The Development And Validation Of An Instrument To Measure Preservice Teacher Self-Efficacy In Regard To The Teaching Of Science Through Inquiry.

Principal Investigator: Mrs. Lori Dira-Smolleck
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(814)863-1691

Co-Investigator: Dr. Carla Zembal-Saul
164B Chambers Building
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(814)865-0827

1. This section provides an explanation of the study in which you will be participating:

A. The study in which you will be participating is part of research intended to explore the development and validation of an instrument to measure preservice teacher self-efficacy in regard to the teaching of science through inquiry.

B. If you agree to take part in this study, you will be asked to complete the Self-Efficacy Beliefs in Regard to Inquiry Science Teaching instrument which will take approximately twenty minutes. In addition, you may be asked to participate in an audiotaped interview.

C. With the exception of the completion of the instrument and the interviews, your participation in this research will not extend beyond your normal involvement with your responsibilities a student of SCIED 458.

D. Each interview is expected to be conducted during a timeframe of approximately one to two hours.

E. This study will involve the use of audiotape recording. Only the investigators will have access to these tapes.

F. All audiotapes, as well as other data, will be stored in a locked cabinet in room 120 Chambers Building. Data will be destroyed after five years.

G. There are no risks or discomforts associated with participation in this study.

H. The potential benefits of participating in this study are as follows: Participation in this study may assist the participants to reflect on their teaching philosophies, make their implicit beliefs explicit and by doing so will be better able to examine their classroom practice which will support their development as teachers.

2. This section describes <u>your rights as a research participant:</u>

A. You may ask any questions about the research procedures and these questions will be answered. Further questions should be directed to the principal investigator, Lori A. Dira-Smolleck.

B. Your participation in this research is <u>confidential</u>. <u>Only</u> the person in charge will have access to your identity and to information that can be associated with your identity. In the event of publication of this research, no personally identifying information will be disclosed.

C. Your participation is voluntary. You are free to stop participation in the research at any time, or to decline to answer any specific questions without penalty.

D. If you have questions concerning the rights of research participants you may contact the Office for Research Protections—(814)865-1775.

3. This section indicates that you are giving your informed consent to participate in the research:

Participant:

I agree to participate in the systematic process of the development and validation of an instrument to measure teacher's self-efficacy in regard to science teaching as an authorized part of the education and research program of The Pennsylvania State University.

I understand the information given to me, and I have received answers to any questions I may have had about the research procedure. I understand and agree to the conditions of this study as described.

To the best of my knowledge and belief, I have no physical or mental illness or difficulties that would increase the risk to me of participation in this study.

I am 18 years of age or older.

I understand that I will receive no compensation for participating.

I understand that my participation in this research is voluntary, and that I may withdraw from this study at any time by notifying the person in charge.

I understand that I will receive a signed copy of this consent form.

____ ______________

Signature **Date**

Researcher:

I certify that the informed consent procedure has been followed, and that I have answered any questions from the participant above as fully as possible.

____ ______________

Signature **Date**

Appendix C

Self-Efficacy Beliefs in Regard to Teaching Science as Inquiry—Version 1

1. Guide students in developing their own questions to examine.
2. Provide meaningful concrete experiences from which questions can be generated.
3. Facilitate open-ended long-term student investigations.
4. Foster a community of learners who work cooperatively in their investigations.
5. Encourage students to ask questions.
6. Encourage students to investigate in an attempt to answer their questions.
7. Have the ability to "let go" of teacher's authority to control and direct student engagement with the curriculum.
8. Willing to negotiate control and authority.
9. Allowing student interests to guide the curriculum.
10. Provide students with opportunities to define the content and direction of the subject matter.
11. Feel confident and possess the ability to make decisions concerning when to ask questions and when to give answers.
12. Support student autonomy in the learning process.
13. Become a critical decision maker.
14. Guide students in asking questions that are meaningful and open avenues for investigation.
15. Guide students to unleash their questions.
16. Pose problems where the methods as well as the answers are left open.
17. Allow for unresolved debates.

18. Allow continuing diversity of problems and methods.
19. Allow for differences in concept and interpretations.
20. Allow students to devise his/her own problems as well as the methods for solving it.
21. Provide opportunities for students to discuss the experiments in which they participated.
22. Welcome and work through the new questions that may arise as a result of discussion.
23. Assign varying problems and plans to groups of students to investigate as a result of queries raised by the students and/or teacher.
24. Discuss reasons for discrepancies among data (findings).
25. Discuss multiple ways of processing and interpreting data.
26. Inject the component of doubt into text material and classroom procedure.
27. Be accepting of honest statements of ignorance, uncertainty, and dubiety.
28. Develop alternative assessments that address the principles and processes of inquiry.
29. Require students to defend their newly acquired knowledge during large and small group discussions
30. Require student to apply and synthesize their knowledge in an effort to support their findings.
31. Provide opportunities for students to construct personal and social meaning of the subject matter.

Appendix D

Reviewers for the TSI Instrument

Faculty Reviewers for the TSI Instrument

Thomas M. Dana, Ph.D.	University of Florida
Karen Eklund, M.Ed.	Pennsylvania State University
Pat Friedrichsen, Ph.D.	University of Missouri
Leigh Ann Haefner, Ph.D.	Pennsylvania State University
Kathleen A. Sillman, Ph.D.	Pennsylvania State University
Carla Zembal-Saul, Ph.D.	Pennsylvania State University

Science Education Graduate Student Reviewers for the TSI Instrument

Roy Boyle	Ph.D. Program
Dwight Schuster	Ph.D Program
Devrim Guvan	Ph.D Program

Appendix E

Self-Efficacy Beliefs in Regard to Teaching Science as Inquiry—Version 2

Please sort statements #1-81 listed on the attached page into the following five categories:

A. Engage in scientifically oriented questions,
B. Give priority to evidence
C. Formulate explanations
D. Evaluate explanations
E. Communicate and justify explanations

1. Read the definition of inquiry that will be used for the purposes of this research.

2. Based on the provided definition of inquiry, read the statements number 1 through 81. Place each statement into the category that you believe best captures the idea(s) presented. Use the attached page to simply place the number of the statement in the appropriate category.

3. If you have suggestions for rewording or rephrasing the given statements, please indicate and provide your suggestions on page 9.

4. In addition, if you have other statements that you would like to see added to the list, please write them on page 9.

INQUIRYDEFINED:

Inquiry is a multifacedted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (National Research Council, 1995, p.23)

STATEMENTS TO CLASSIFY

1. The teacher is generally responsible for planning investigations

2. While students are devising ways through which they can create explanations, I will be able to offer multiple suggestions for interpreting data.

3. As a teacher of science I am typically able to structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.

4. Through the process of sharing explanations, I will be able to provide students with the opportunity to suggest alternative explanations for the same observations.

5. As a teacher of science, I possess the ability to provide meaningful concrete experiences from which children can generate scientific questions.

6. As a teacher, I have the necessary skills to determine the best manner through which children can obtain scientific evidence.

7. I believe that I will be fluent in discussing and devising plans to groups of student for investigation as a result of queries raised by the students.

8. As a science teacher I possess the ability to allow for unresolved debates where there may be no single correct answer.

9. I believe that it is critical to require students to defend their newly acquired knowledge during large and/or small group discussions.

10. I will be able to require students to apply their knowledge in an effort to support their findings.

11. I believe that I will be able to assign varying problems to groups of students to investigate as a result of queries raised by the students.

12. I will be able to engage students in designing the learning environment in an attempt to allow for diversity of problems and methods.

13.The teacher is responsible for guiding students in developing their own questions to examine through scientific investigation.

14. As a teacher I will be fluent in providing opportunities through which children can obtain evidence from observations and measurements.

15. A science teacher should encourage children to make the results of their investigations public.

16. Students should be provided with opportunities to become critical decision makers when evaluating the validity of scientific explanations.

17. I will be able to guide students in asking scientific questions that are meaningful.

18. As a teacher of science, I will be able to guide students in self-assessment of their explanations.

19. Students describing their investigations in ways that enable others to repeat the investigation is a critical component of science learning.

20. As a teacher of science, I will be able to assist students in determining the strengths and weaknesses of their claims.

21. As a science teacher I will create (plan) investigations through which students can gather evidence.

22. Through the process of sharing explanations, I will be able to provide students with the opportunity to identify faulty reasoning.

23. Through the process of sharing explanations, I will be able to facilitate student questioning of possible connections between/among explanations.

24. As a science teacher I will be able to offer multiple avenues through which students can investigate scientific phenomena.

25. Students should develop explanations using what they already know about the world.

26. As a teacher I will be able to support the modification of student explanations debated within our community of scientists.

27. I possess the ability to orchestrate discourse among students about scientific ideas.

28. As a teacher I encompass the ability to encourage students to review and ask questions about the results of other scientists' work

29. I will be able to guide student toward appropriate investigations depending on the questions they are attempting to answer.

30. The majority of scientific questions should originate from the teacher. (learner, instructional materials)

31. I possess the ability to "let go" and allow students to devise his/her own problems to investigate.

32. Through investigations students will be able to construct personal meaning of the subject matter.

33. During the evaluation of explanations, as a science teacher I will be able to discuss with my students reasons for discrepancies among data and findings.

34. As a teacher of science I will be able to determine if the explanation presented by the students adequately answer the proposed question.

35. When teaching science I will be able to allow students to have a significant voice in decisions about the content and context of their work.

36. As a teacher of science, I am able to support the gathering and using of data to develop explanations for scientific phenomena.

37. When students evaluate their own explanations as well as other students, I will be able to be accepting of honest statements of ignorance, uncertainty, and dubiety.

38. I will play a critical role in guiding the identification of scientific questions.

39. I will be able to guide student toward building new ideas upon their current understandings of science.

40. I possess the techniques / strategies necessary to provide students with opportunities to become critical decision makers.

41. As a teacher of science I will be able to determine if the evidence provided supports the proposed explanation.

42. As a teacher of science, I will be able to provide meaningful opportunities for students to critically discuss the experiments in which they participated.

43. Through the process of sharing explanations, I will be able to facilitate students toward the recognition of the connections students have made among the evidence, existing scientific knowledge and their proposed explanations.

44. Teachers should encourage students to ask scientific questions.

45. I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence about nature.

46. As a teacher of science I will be able to determine if there are any apparent biases or flaws in the reasoning connecting evidence and explanation to the proposed question(s).

47. I feel confident that I will be able to ensure that students make the connection between their results and scientific knowledge appropriate to their level of development.

48. The science teacher is generally responsible for developing questions for investigation.

49. Through investigations I will be able to assist students in constructing social meaning of the subject matter.

50. I possess the skills necessary for encouraging my student to create scientific explanations that provide causes for effects and establish relationships based on evidence and logical argument.

51. Throughout the process of inquiry, I will be able to welcome and work through the new questions that may arise as a result of discussion.

52. As a teacher of science I will be able to determine if other reasonable explanations can be derived from the evidence.

53. As a teacher of science, I will be able to assist students in solidifying an empirically based argument.

54. The majority of evidence is derived from instructional materials such as a text book.

55. In an attempt to allow for diversity, I will be able to negotiate control and authority while students are investigating to form explanations.

56. When students are communicating and justifying their explanations, I believe that I will be able to make decisions concerning when to ask questions and when to give answers.

57. As a science teacher, I will be able to encourage student to investigate scientific phenomena in an attempt to answer their questions.

58. I am able to determine if questions are accessible.

59. While students are devising ways through which they can create explanations, I will be able to offer multiple suggestions for processing data.

60. When students evaluate their own explanations as well as others, I will be able to inject the component of doubt into their thinking.

61. I will be able to facilitate the clear articulation of explanations from students.

62. Through the process of sharing explanations, I will be able to provide students with the opportunity to point out statements that go beyond the evidence.

63. As a science teacher, I will encourage students to ask questions that probe rather than require specific answers.

64. I am able to determine if questions are appropriate to the students' developmental level.

65. I will require my students to build upon their existing knowledge base to create explanations that go beyond current knowledge and propose some new understanding.

66. As a teacher, I will be able to support the idea of skepticism in an attempt to further student knowledge.

67. Through the process of sharing explanations, I will be able to provide students with the opportunity to ask questions

68. Students should justify their decisions by drawing on evidence to create a scientific claim

69. As a teacher of science I will be able to guide the students toward thinking about other reasonable explanations that can be derived from the evidence presented.

70. I will be able to facilitate open-ended long-term student investigations in an attempt to provide opportunities for students to gather evidence.

71. I will be able to help students focus their questions so that they can experience both interesting and productive investigations.

72. I can (will) do a great deal as a science teacher to unleash student questions.

73. I feel confident that I will be able to ensure that student explanations are consistent with currently accepted scientific knowledge.

74. As a teacher of science, I will be able to assist students in resolving contradictions.

75. I will be able to allow for differences in student interpretations of scientific phenomena.

76. I am able to determine if questions are manageable.

77. As a teacher I will be able to pose problems where the methods of investigation are open to student autonomy.

78. Through the process of sharing explanations, I will be able to provide students with the opportunity to examine evidence.

79. I will be able to assist students in focusing their queries into manageable questions for investigation.

80. I will be able to require students to synthesize their knowledge in an effort to support their findings.

81. Students should develop explanations using observations.

Place the number of the corresponding statement in the chart that represents the category to which you believe it belongs

A. Engage in Scientifically Oriented Questions				

B. Give Priority to Evidence				

C. Formulate Explanations from Evidence				

E. Communicate and Justify Explanations				

D. Evaluate Explanations				

F. Other				

1. If you have **<u>suggestions for rewording or rephrasing</u>** the statements provided, please indicate the statement, the corresponding number and your suggestion below.

2. If you have other **statements that you would like to see added** to the list, please list them below.

Appendix F

Self-Efficacy Beliefs in Regard to Teaching Science as Inquiry—Version 3

1) As a science teacher I will be responsible for planning all scientific investigations.

2) While students are devising ways through which they can create explanations, I will be able to offer multiple suggestions for interpreting data.

3) As a teacher of science I am typically able to structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.

4) As a science teacher, I will be able to provide students with the opportunity to suggest alternative explanations for the same observations.

5) As a science teacher, I will encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.

6) As a teacher of science, I possess the ability to provide meaningful concrete experiences from which children can generate scientific questions.

7) As a teacher, I have the necessary skills to determine the best manner through which children can obtain scientific evidence.

8) As a teacher of science, I will be able to devise plans for groups of student for investigation as a result of queries raised by the students.

9) As a science teacher, I will require students to defend their newly acquired knowledge during large and/or small group discussions.

10) I will be able to require students to use their knowledge in an effort to support their findings.

11) As a science teacher, I will be able to assign varying problems to groups of students to investigate as a result of queries raised by the students.

12) I will be able to provide students opportunities to design the learning environment in an attempt to allow for diversity of problems and methods.

13) As a science teacher, I will guide students in developing their own questions to examine through scientific investigation.

14) As a teacher I will be fluent in providing opportunities through which children can obtain evidence from observations and measurements.

15) As a science teacher, I will encourage children to make the results of their investigations public.

16) As a science teacher, I will provide opportunities for students to become critical decision makers when evaluating the validity of scientific explanations.

17) I will be able to guide students in asking scientific questions that are meaningful.

18) As a teacher of science, I will be able to guide students in self-assessment of their explanations.

19) As a science teacher I will provide opportunities for my students to describe their investigations and findings to the rest of the class in an attempt to enhance science learning.

20) As a teacher of science, I will be able to assist students in determining the strengths and weaknesses of their claims.

21) As a science teacher I will create (plan) investigations through which students can gather evidence.

22) Through the process of sharing explanations, I will be able to provide students with the opportunity to identify faulty reasoning.

23) Through the process of sharing explanations, I will be able to facilitate student questioning of possible connections between/among explanations.

24) As a science teacher, I will require students to develop explanations using what they already know about the world.

25) As a science teacher, I will require students to develop explanations using existing scientific knowledge.

26) As a teacher I will be able to support the modification of student explanations debated within our classroom.

27) I possess the ability to orchestrate discourse among students about scientific ideas.

28) As a teacher I encompass the ability to encourage students to review and ask questions about the results of other scientists' work

29) I will be able to guide student toward appropriate investigations depending on the questions they are attempting to answer.

30) As a science teacher, I will create the majority of the scientific questions.

31) I possess the ability to “let go” and allow students to devise his/her own problems to investigate.

32) Through investigations students will be able to construct personal meaning of the subject matter.

33) During the evaluation of explanations, as a science teacher I will be able to discuss with my students reasons for discrepancies among data and findings.

34) When teaching science I will allow students to have a significant voice in decisions about the content and context of their work.

35) As a teacher of science, I am able to guide students in the gathering and using of data to develop explanations.

36) When students evaluate their own explanations as well as other students, I will be able to be accepting of honest statements of ignorance, uncertainty, and dubiety.

37) I will play a critical role in guiding the identification of scientific questions.

38) I will be able to guide student toward building new ideas upon their current understandings of science.

39) I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations.

40) As a teacher of science, I will be able to provide meaningful opportunities for students to critically discuss the experiments in which they participated.

41) Through the process of sharing explanations, I will be able to facilitate students toward the recognition of the connections students have made among the evidence, existing scientific knowledge and their proposed explanations.

42) As a science teacher, I will encourage students to ask scientific questions.

43) I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence about nature.

44) As a teacher of science I will be able to determine if there are any apparent biases or flaws in the reasoning connecting evidence and explanation to the proposed question(s).

45) I feel confident that I will be able to ensure that students make the connection between their results and scientific knowledge appropriate to their level of development.

46) As a science teacher, I will develop questions for students to investigate.

47) Through investigations I will be able to assist students in connecting their learning to societal issues.

48) I possess the skills necessary for encouraging my student to create scientific explanations that provide causes for effects and establish relationships based on evidence and logical argument.

49) Throughout the process of inquiry, I will be able to welcome and work through the new questions that may arise as a result of discussion.

50) As a science teacher, most of the scientific evidence will be derived from instructional materials such as a textbook.

51) When students are communicating and justifying their explanations, I will be able to make decisions concerning when to ask questions and when to give answers.

52) As a science teacher, I will be able to encourage student to investigate scientific phenomena in an attempt to answer their questions.

53) I am able to determine if questions are accessible.

54) While students are devising ways through which they can create explanations, I will be able to offer multiple suggestions for processing data.

55) When students evaluate their own explanations as well as others, I will be able to inject the component of doubt into their thinking.

56) I will be able to facilitate the clear articulation of explanations from students.

57) Through the process of sharing explanations, I will be able to provide students with the opportunity to point out statements that go beyond the evidence.

58) As a science teacher, I will encourage students to ask questions that probe rather than require specific answers.

59) I am able to determine if questions are appropriate to the students' developmental level.

60) I will require my students to build upon their existing knowledge base to create explanations that go beyond their current knowledge and propose some new understanding.

61) As a teacher of science, I will be able to support the idea of skepticism.

62) Through the process of sharing explanations, I will be able to provide students with the opportunity to ask questions

63) As a science teacher, I will require students to create scientific claims to justify their decisions based on observational evidence.

64) As a teacher of science I will be able to guide the students toward thinking about other reasonable explanations that can be derived from the evidence presented.

65) I will be able to facilitate open-ended long-term student investigations in an attempt to provide opportunities for students to gather evidence.

66) I will be able to help students focus their questions so that they can experience both interesting and productive investigations.

67) I can (will) do a great deal as a science teacher to unleash student questions.

68) I feel confident that I will be able to ensure that students support their explanations by proving that they are consistent with currently accepted scientific knowledge.

69) As a teacher of science, I will be able to assist students in resolving contradictions.

70) I am able to determine if questions are manageable.

71) As a teacher I will be able to pose problems where the methods of investigation are open to student autonomy.

72) As a science teacher, I allow students opportunities to examine evidence.

73) I will be able to assist students in focusing their queries into manageable questions for investigation.

74) I will be able to require students to discuss their scientific claims and findings in an effort to support their learning.

75) As a science teacher, I will require students to develop explanations using evidence from observations.

76) As a science teacher, I will utilize worksheets as an instructional tool.

77) As a science teacher, I will provide my students with scientific knowledge through the use of lectures.

78) As a teacher of science, I will require my students to follow a prescribed list of steps or procedures when they are communicating their results with the class.

79) As the science teacher, I will provide my students with possible connections to scientific knowledge through which they can relate their explanations.

80) As a science teacher, I will provide my students with evidence that can be used to develop their explanations.

81) As a science teacher, I will engage my students in questions that are provided by me.

82) As a science teacher, I will engage my students in questions that are provided in the textbook.

83) When studying a given scientific phenomenon, I will provide my students with the appropriate data and instruct them on the steps necessary to analyze it.

84) As a science teacher, I will provide my students with questions for investigations however, I expect my students to clarify the questions in an attempt to enhance science learning.

85) As a teacher of science, I will instruct my students as to what data is to be collected when they are investigating a given topic.

86) As a science teacher, I will provide students with broad guidelines pertaining to how they are to communicate and justify their explanations to the class.

87) As a science teacher, when I begin a unit of study, my students will be able to choose from among a list of questions, the questions they would like to investigate.

88) As a science teacher, I will provide data for the students to analyze in a particular manner.

89) As a science teacher, I will provide my students with all of the necessary evidence required to form their explanations.

90) Through the use of lecture and textbook readings, all evidence required to form explanations will be provided to my students.

91) As a science teacher, I will provide my students with possible ways to use evidence to create explanations.

92) As a science teacher, I will expect my students to follow certain procedures when justifying their explanations.

93) As a science teacher, I will allow my students the freedom to determine what evidence would be most useful for answering their question.

94) As a teacher of science, I will permit my students to design their own investigations to gather the evidence necessary to answer a particular question.

Appendix G

Self-Efficacy Beliefs in Regard to Teaching Science as Inquiry—Version 4

1) As a teacher of science, I will be able to offer multiple suggestions for creating explanations from data.

2) As a science teacher, I will be able to provide students with the opportunity to construct alternative explanations for the same observations.

3) As a science teacher, I will encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.

4) As a teacher of science, I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students.

5) As a teacher, I have the necessary skills to determine the best manner through which children can obtain scientific evidence.

6) As a science teacher, I will require students to defend their newly acquired knowledge during large and/or small group discussions.

7) As a science teacher, I will guide students in developing their own questions to examine through scientific investigation.

8) As a teacher I will be fluent in providing opportunities through which children can obtain evidence from observations and measurements.

9) As a science teacher, I will encourage children to make the results of their investigations public.

10) As a science teacher, I will provide opportunities for students to become critical decision makers when evaluating the validity of scientific explanations.

11) I will be able to guide students in asking scientific questions that are meaningful.

12) As a science teacher I will provide opportunities for my students to describe their investigations and findings to the rest of the class in light of their evidence justify explanations and how it was collected.

13) As a science teacher I will create (plan) investigations through which students can gather particular evidence.

14) As a teacher of science, I will be able to negotiate with students possible connections between/among explanations.

15) As a science teacher, I will require students to develop explanations using what they already know about scientifically accepted ideas.

16) As a teacher I encompass the ability to encourage students to review and ask questions about the results of other students' work

17) I will be able to guide student toward appropriate investigations depending on the questions they are attempting to answer.

18) As a science teacher, I will create the majority of the scientific questions needed for investigation.

19) I possess the ability to allow students to devise their own problems to investigate.

20) As a teacher of science, I am able to guide students in using data to develop explanations.

21) I will play the primary role in guiding the identification of scientific questions.

22) I will be able to guide student's toward scientifically accepted ideas upon which they can develop more meaningful understandings of science.

23) I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations.

24) As a teacher of science, I will be able to help students recognize the connections existing between proposed explanations and scientific knowledge.

25) As a science teacher, I will encourage students to ask scientific questions.

26) I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence.

27) As a science teacher, I will develop questions for students to investigate.

28) As a science teacher, I will encourage my student to create scientific explanations based on evidence.

29) As a science teacher, most of the scientific evidence will be derived from instructional materials such as a textbook.

30) As a science teacher, I will be able to encourage student to investigate scientific phenomena in an attempt to answer their questions.

31) As a teacher of science, I will be able to offer model approached for generating explanations from evidence.

32) I will be able to support students clear articulation of explanations.

33) Through the process of sharing explanations, I will be able to provide students with the opportunity to critique explanations and investigation methods.

34) As a science teacher, I will require students to create scientific claims based on observational evidence.

35) As a teacher of science I will be able to guide the students toward thinking about other reasonable explanations that can be derived from the evidence presented.

36) I will be able to facilitate open-ended long-term student investigations in an attempt to provide opportunities for students to gather evidence.

37) I will be able to help students refine questions posed by the teacher or instructional materials so that they can experience both interesting and productive investigations.

38) I will be able to assist students in focusing their queries from observing a demonstration into manageable questions for investigation.

39) As a science teacher, I will require students to develop explanations using evidence.

40) As a science teacher, I will utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process.

41) As a science teacher, I will provide my students with scientific knowledge that can be used to refine their explanations.

42) As a teacher of science, I will require my students to follow prescribed steps or procedures when they are communicating their results with the class.

43) As the science teacher, I will provide my students with possible connections to scientific knowledge through which they can relate their explanations.

44) As a science teacher, I will provide my students with evidence to be analyzed.

45) As a science teacher, I will engage my students in questions that are provided by me.

46) As a science teacher, I will engage my students in questions that are provided by a variety of sources such as the textbook.

47) When studying a given scientific phenomenon, I will provide my students with the appropriate data and instruct them on the steps necessary to analyze it.

48) As a science teacher, I will provide my students with questions for investigations however, I expect my students to clarify the questions in an attempt to enhance science learning.

49) As a teacher of science, I will provide my students with the data needed to support an investigation.

50) As a science teacher, I will provide students with broad guidelines pertaining to how they are to communicate and justify their explanations to the class.

51) As a science teacher, when I begin a unit of study, my students will be able to choose from among a list of questions, the questions they would like to investigate.

52) As a science teacher, I will provide data for the students to analyze in a particular manner.

53) As a science teacher, I will provide my students with all of the necessary evidence required to form their explanations.

54) Through the use of lecture and textbook readings, all evidence required to form explanations will be provided to my students.

55) As a science teacher, I will provide my students with a framework for constructing explanations from evidence.

56) As a science teacher, I will expect my students to follow predetermined procedures when justifying their explanations.

57) As a science teacher, I will allow my students the freedom to determine what evidence would be most useful for answering their question.

58) As a teacher of science, I will permit my students to design their own investigations to gather the evidence necessary to answer a particular question.

59) As a science teacher, I will work with my students to construct criteria for sharing and critiquing explanations.

60) As a teacher of science, I will provide students with broad guidelines for sharing and critiquing explanations.

61) As a teacher of science, I will have students use internet based resources or other materials to further develop their investigations.

62) As a teacher of science, I will model for my students the guidelines to be followed when sharing and critiquing explanations.

63) As a science teacher, I will have students evaluate the consistency between their own explanations and scientifically accepted ideas.

64) As a science teacher, I will negotiate with my students the criteria for sharing and critiquing explanations.

65) As a science teacher, I will construct with students the guidelines for communicating results and explanations.

Appendix H

Self-Efficacy Beliefs in Regard to Teaching Science as Inquiry—Version 5

Please indicate the degree to which you agree or disagree with each statement below by circling in the appropriate number as indicated below.

5	=	Strongly Agree
4	=	Agree
3	=	Uncertain
2	=	Disagree
1	=	Strongly Disagree

	Strongly Agree				**Strongly Disagree**
1. As a teacher of science, I will be able to offer multiple suggestions for creating explanations from data.	5	4	3	2	1
2. As a science teacher, I will be able to provide students with the opportunity to construct alternative explanations for the same observations.	5	4	3	2	1
3. As a science teacher, I will encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.	5	4	3	2	1
4. As a teacher of science, I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students.	5	4	3	2	1
5. As a teacher, I have the necessary skills to determine the best manner through which children can obtain scientific evidence.	5	4	3	2	1
6. As a science teacher, I will require students to defend their newly acquired knowledge during large and/or small group discussions.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
7. As a science teacher, I will guide students in developing their own questions to examine through scientific investigation.	5	4	3	2	1
8. As a teacher I will be fluent in providing opportunities through which children can obtain evidence from observations and measurements.	5	4	3	2	1
9. As a science teacher, I will encourage children to make the results of their investigations public.	5	4	3	2	1
10. As a science teacher, I will provide opportunities for students to become critical decision makers when evaluating the validity of scientific explanations.	5	4	3	2	1
11. I will be able to guide students in asking scientific questions that are meaningful.	5	4	3	2	1
12. As a science teacher I will provide opportunities for my students to describe their investigations and findings to the rest of the class in light of their evidence justify explanations and how it was collected.	5	4	3	2	1
13. As a science teacher I will create (plan) investigations through which students can gather particular evidence.	5	4	3	2	1
14. As a teacher of science, I will be able to negotiate with students possible connections between/among explanations.	5	4	3	2	1
15. As a science teacher, I will require students to develop explanations using what they already know about scientifically accepted ideas.	5	4	3	2	1
16. As a teacher I encompass the ability to encourage students to review and ask questions about the results of other students' work.	5	4	3	2	1
17. I will be able to guide student toward appropriate investigations depending on the questions they are attempting to answer.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
18. As a science teacher, I will create the majority of the scientific questions needed for investigation.	5	4	3	2	1
19. I possess the ability to allow students to devise their own problems to investigate.	5	4	3	2	1
20. As a teacher of science, I am able to guide students in using data to develop explanations.	5	4	3	2	1
21. I will play the primary role in guiding the identification of scientific questions.	5	4	3	2	1
22. I will be able to guide student's toward scientifically accepted ideas upon which they can develop more meaningful understandings of science.	5	4	3	2	1
23. I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations.	5	4	3	2	1
24. As a teacher of science, I will be able to help students recognize the connections existing between proposed explanations and scientific knowledge.	5	4	3	2	1
25. As a science teacher, I will encourage students to ask scientific questions.	5	4	3	2	1
26. I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence.	5	4	3	2	1
27. As a science teacher, I will develop questions for students to investigate.	5	4	3	2	1
28. As a science teacher, I will encourage my student to create scientific explanations based on evidence.	5	4	3	2	1
29. As a science teacher, most of the scientific evidence will be derived from instructional materials such as a textbook.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
30. As a science teacher, I will be able to encourage student to investigate scientific phenomena in an attempt to answer their questions.	5	4	3	2	1
31. As a teacher of science, I will be able to offer model approached for generating explanations from evidence.	5	4	3	2	1
32. I will be able to support students clear articulation of explanations.	5	4	3	2	1
33. Through the process of sharing explanations, I will be able to provide students with the opportunity to critique explanations and investigation methods.	5	4	3	2	1
34. As a science teacher, I will require students to create scientific claims based on observational evidence.	5	4	3	2	1
35. As a teacher of science I will be able to guide the students toward thinking about other reasonable explanations that can be derived from the evidence presented.	5	4	3	2	1
36. I will be able to facilitate open-ended long-term student investigations in an attempt to provide opportunities for students to gather evidence.	5	4	3	2	1
37. I will be able to help students refine questions posed by the teacher or instructional materials so that they can experience both interesting and productive investigations.	5	4	3	2	1
38. I will be able to assist students in focusing their queries from observing a demonstration into manageable questions for investigation.	5	4	3	2	1
39. As a science teacher, I will require students to develop explanations using evidence.	5	4	3	2	1
40. As a science teacher, I will utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
41. As a science teacher, I will provide my students with scientific knowledge that can be used to refine their explanations.	5	4	3	2	1
42. As a teacher of science, I will require my students to follow prescribed steps or procedures when they are communicating their results with the class.	5	4	3	2	1
43. As the science teacher, I will provide my students with possible connections to scientific knowledge through which they can relate their explanations.	5	4	3	2	1
44. As a science teacher, I will provide my students with evidence to be analyzed.	5	4	3	2	1
45. As a science teacher, I will engage my students in questions that are provided by me.	5	4	3	2	1
46. As a science teacher, I will engage my students in questions that are provided by a variety of sources such as the textbook.	5	4	3	2	1
47. When studying a given scientific phenomenon, I will provide my students with the appropriate data and instruct them on the steps necessary to analyze it.	5	4	3	2	1
48. As a science teacher, I will provide my students with questions for investigations however, I expect my students to clarify the questions in an attempt to enhance science learning.	5	4	3	2	1
49. As a teacher of science, I will provide my students with the data needed to support an investigation.	5	4	3	2	1
50. As a science teacher, I will provide students with broad guidelines pertaining to how they are to communicate and justify their explanations to the class.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
51. As a science teacher, when I begin a unit of study, my students will be able to choose from among a list of questions, the questions they would like to investigate.	5	4	3	2	1
52. As a science teacher, I will provide data for the students to analyze in a particular manner.	5	4	3	2	1
53. As a science teacher, I will provide my students with all of the necessary evidence required to form their explanations.	5	4	3	2	1
54. Through the use of lecture and textbook readings, all evidence required to form explanations will be provided to my students.	5	4	3	2	1
55. As a science teacher, I will provide my students with a framework for constructing explanations from evidence.	5	4	3	2	1
56. As a science teacher, I will expect my students to follow predetermined procedures when justifying their explanations.	5	4	3	2	1
57. As a science teacher, I will allow my students the freedom to determine what evidence would be most useful for answering their question.	5	4	3	2	1
58. As a teacher of science, I will permit my students to design their own investigations to gather the evidence necessary to answer a particular question.	5	4	3	2	1
59. As a science teacher, I will work with my students to construct criteria for sharing and critiquing explanations.	5	4	3	2	1
60. As a teacher of science, I will provide students with broad guidelines for sharing and critiquing explanations.	5	4	3	2	1
61. As a teacher of science, I will have students use internet based resources or other materials to further develop their investigations.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
62. As a teacher of science, I will model for my students the guidelines to be followed when sharing and critiquing explanations.	5	4	3	2	1
63. As a science teacher, I will have students evaluate the consistency between their own explanations and scientifically accepted ideas.	5	4	3	2	1
64. As a science teacher, I will negotiate with my students the criteria for sharing and critiquing explanations.	5	4	3	2	1
65. As a science teacher, I will construct with students the guidelines for communicating results and explanations.	5	4	3	2	1

Appendix I

Self-Efficacy Beliefs in Regard to Teaching Science as Inquiry—Version 6

Please indicate the degree to which you agree or disagree with each statement below by shaping in the appropriate letters on the scan sheet.

5	=	Strongly Agree
4	=	Agree
3	=	Uncertain
2	=	Disagree
1	=	Strongly Disagree

	Strongly Agree				**Strongly Disagree**
1. As a teacher of science, I will be able to offer multiple suggestions for creating explanations from data.	5	4	3	2	1
2. As a science teacher, I will be able to provide students with the opportunity to construct alternative explanations for the same observations.	5	4	3	2	1
3. As a science teacher, I will be able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.	5	4	3	2	1
4. As a teacher of science, I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students.	5	4	3	2	1
5. As a teacher, I have the necessary skills to determine the best manner through which children can obtain scientific evidence.	5	4	3	2	1
6. As a science teacher, I will require students to defend their newly acquired knowledge during large and/or small group discussions.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
7. As a science teacher, I will be able to guide students in developing their own questions to examine through scientific investigation.	5	4	3	2	1
8. As a teacher I will be fluent in providing opportunities through which children can obtain evidence from observations and measurements.	5	4	3	2	1
9. As a science teacher, I will require children to make the results of their investigations public.	5	4	3	2	1
10. As a science teacher, I will expect students to become critical decision makers when evaluating the validity of scientific explanations.	5	4	3	2	1
12. I will be able to guide students in asking scientific questions that are meaningful.	5	4	3	2	1
13. As a science teacher I will require my students to describe their investigations and findings to the rest of the class in light of their evidence, justify explanations and how data was collected.	5	4	3	2	1
14. As a science teacher I will create (plan) investigations through which students will be required to gather particular evidence.	5	4	3	2	1
15. As a teacher of science, I will be able to negotiate with students possible connections between/among explanations.	5	4	3	2	1
16. As a science teacher, I will require students to develop explanations using what they already know about scientifically accepted ideas.	5	4	3	2	1
17. As a teacher I expect students to review and ask questions about the results of other students' work.	5	4	3	2	1
18. I will be able to guide student toward appropriate investigations depending on the questions they are attempting to answer.	5	4	3	2	1

	Strongly Agree			**Strongly Disagree**	
19. As a science teacher, I will be able to create the majority of the scientific questions needed for investigation.	5	4	3	2	1
20. I possess the ability to allow students to devise their own problems to investigate.	5	4	3	2	1
21. As a teacher of science, I am able to guide students in using data to develop explanations.	5	4	3	2	1
22. I will be able to play the primary role in guiding the identification of scientific questions.	5	4	3	2	1
23. I will be able to guide student's toward scientifically accepted ideas upon which they can develop more meaningful understandings of science.	5	4	3	2	1
24. I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations.	5	4	3	2	1
25. As a teacher of science, I will expect students to recognize the connections existing between proposed explanations and scientific knowledge.	5	4	3	2	1
26. As a science teacher, I will require students to ask scientific questions.	5	4	3	2	1
27. I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence.	5	4	3	2	1
28. As a science teacher, I will be able to develop questions for students to investigate.	5	4	3	2	1
29. As a science teacher, I will expect my students to create scientific explanations based on evidence.	5	4	3	2	1
30. As a science teacher, I expect students to derive most of the scientific evidence instructional materials such as a textbook.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
31. As a science teacher, I will be able to encourage students to investigate scientific phenomena in an attempt to answer their questions.	5	4	3	2	1
32. As a teacher of science, I will be able to offer/model approaches for generating explanations from evidence.	5	4	3	2	1
33. As a science teacher, I will be able to support students clear articulation of explanations.	5	4	3	2	1
34. Through the process of sharing explanations, I will be able to provide students with the opportunity to critique explanations and investigation methods.	5	4	3	2	1
35. As a science teacher, I will require students to create scientific claims based on observational evidence.	5	4	3	2	1
36. As a teacher of science I will be able to guide the students toward thinking about other reasonable explanations that can be derived from the evidence presented.	5	4	3	2	1
37. As a science teacher, I will be able to facilitate open-ended long-term student investigations. (in an attempt to provide opportunities for students to gather evidence)	5	4	3	2	1
38. I will be able to help students refine questions posed by the teacher or instructional materials so that they can experience both interesting and productive investigations.	5	4	3	2	1
39. I will be able to assist students in focusing their queries from observing a demonstration into manageable questions for investigation.	5	4	3	2	1
40. As a science teacher, I will require students to develop explanations using evidence.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
41. As a science teacher, I will be able to utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process.	5	4	3	2	1
42. As a science teacher, I will be able to provide my students with scientific knowledge that can be used to refine their explanations.	5	4	3	2	1
43. As a teacher of science, I will require my students to follow prescribed steps or procedures when they are communicating their results with the class.	5	4	3	2	1
44. As the science teacher, I will be able to provide my students with possible connections to scientific knowledge through which they can relate their explanations.	5	4	3	2	1
45. As a science teacher, I will be able to provide my students with evidence to be analyzed.	5	4	3	2	1
46. As a science teacher, I will expect my students to engage in questions that are provided by me.	5	4	3	2	1
47. As a science teacher, I will expect my students to engage in questions that are provided by a variety of sources such as the textbook.	5	4	3	2	1
48. When studying a given scientific phenomenon, I will be able to provide my students with the appropriate data and instruct them on the steps necessary to analyze it.	5	4	3	2	1
49. As a science teacher, I will be able to provide my students with questions for investigations however, I expect my students to clarify the questions in an attempt to enhance science learning.	5	4	3	2	1
50. As a teacher of science, I will be able to provide my students with the data needed to support an investigation.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
51. As a science teacher, I will be able to provide students with broad guidelines pertaining to how they are to communicate and justify their explanations to the class.	5	4	3	2	1
52. As a science teacher, when I begin a unit of study, my students will be able to choose from among a list of questions, the questions they would like to investigate.	5	4	3	2	1
53. As a science teacher, I will be able to provide data for the students to analyze in a particular manner.	5	4	3	2	1
54. As a science teacher, I will be able to provide my students with all of the necessary evidence required to form their explanations.	5	4	3	2	1
55. As a science teacher, I will be able to provide my students with all evidence required to form explanations through the use of lecture and textbook readings.	5	4	3	2	1
56. As a science teacher, I will be able to provide my students with a framework for constructing explanations from evidence.	5	4	3	2	1
57. As a science teacher, I will expect my students to follow predetermined procedures when justifying their explanations.	5	4	3	2	1
58. As a science teacher, I will be able to allow my students the freedom to determine what evidence would be most useful for answering their question.	5	4	3	2	1
59. As a teacher of science, I will expect my students to design their own investigations to gather the evidence necessary to answer a particular question.	5	4	3	2	1
60. As a science teacher, I will be able to work with my students to construct criteria for sharing and critiquing explanations.	5	4	3	2	1

	Strongly Agree			Strongly Disagree	
61. As a teacher of science, I will be able to provide students with broad guidelines for sharing and critiquing explanations.	5	4	3	2	1
62. As a teacher of science, I will require students use internet based resources or other materials to further develop their investigations.	5	4	3	2	1
63. As a teacher of science, I will be able to model for my students the guidelines to be followed when sharing and critiquing explanations.	5	4	3	2	1
64. As a science teacher, I will have expect students to evaluate the consistency between their own explanations and scientifically accepted ideas.	5	4	3	2	1
65. As a science teacher, I will be able to negotiate with my students the criteria for sharing and critiquing explanations.	5	4	3	2	1
66. As a science teacher, I will be able to construct with students the guidelines for communicating results and explanations.	5	4	3	2	1

Appendix J

Self-Efficacy Beliefs in Regard to Teaching Science as Inquiry—Version 7

Student Number: ______________________ **Circle One:** Male Female

Please indicate the degree to which you agree or disagree with each statement below by circling in the appropriate number as indicated below.

5	=	Strongly Agree
4	=	Agree
3	=	Uncertain
2	=	Disagree
1	=	Strongly Disagree

	Strongly Agree				**Strongly Disagree**
1. As a teacher of science, I will be able to offer multiple suggestions for creating explanations from data.	5	4	3	2	1
2. As a science teacher, I will be able to provide students with the opportunity to construct alternative explanations for the same observations.	5	4	3	2	1
3. As a science teacher, I will be able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.	5	4	3	2	1
4. As a teacher of science, I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students.	5	4	3	2	1
5. As a science teacher, I have the necessary skills to determine the best manner through which children can obtain scientific evidence.	5	4	3	2	1
6. As a science teacher, I will require students to defend their newly acquired knowledge during large and/or small group discussions.	5	4	3	2	1

	Strongly Agree			**Strongly Disagree**	
7. When I am a science teacher, my students will select among a list of given questions while investigating scientific phenomena.	5	4	3	2	1
8. As a science teacher, I will provide opportunities through which children will obtain evidence from observations and measurements.	5	4	3	2	1
9. As a science teacher, I will expect my students to make the results of their investigations public.	5	4	3	2	1
10. As a science teacher, I will be able to provide opportunities for students to become the critical decision makers when evaluating the validity of scientific explanations.	5	4	3	2	1
11. I will be able to guide students in asking scientific questions that are meaningful.	5	4	3	2	1
12. As a science teacher, I will be able to provide opportunities for my students to describe their investigations and findings to others using their evidence to justify explanations and how data was collected.	5	4	3	2	1
13. As a science teacher, I will create (plan) investigations through which students will be expected to gather particular evidence.	5	4	3	2	1
14. As a teacher of science, I will be able to negotiate with students possible connections between/among explanations.	5	4	3	2	1
15. As a science teacher, I will expect students to independently develop explanations using what they already know about scientifically accepted ideas.	5	4	3	2	1
16. As a science teacher, I encompass the ability to encourage students to review and ask questions about the results of other students' work.	5	4	3	2	1

	Strongly Agree			Strongly Disagree	
17. I will be able to guide students toward appropriate investigations depending on the questions they are attempting to answer.	5	4	3	2	1
18. As a science teacher, I will be able to create the majority of the scientific questions needed for students to investigate.	5	4	3	2	1
19. I possess the ability to allow students to devise their own problems to investigate.	5	4	3	2	1
20. When I am a teacher of science, my students will make use of data in order to develop explanations as a result of teacher guidance.	5	4	3	2	1
21. I will be able to play the primary role in guiding the identification of scientific questions.	5	4	3	2	1
22. I will be able to guide students toward scientifically accepted ideas upon which they can develop more meaningful understandings of science.	5	4	3	2	1
23. I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations.	5	4	3	2	1
24. As a teacher of science, I will expect students to recognize the connections existing between proposed explanations and scientific knowledge.	5	4	3	2	1
25. As a science teacher, I will expect students to ask scientific questions.	5	4	3	2	1
26. I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence.	5	4	3	2	1
27. When I am a science teacher, my students will investigate questions I have developed.	5	4	3	2	1
28. When I am a science teacher, my students will create scientific explanations based on evidence as a result of teacher assistance.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
29. When I am a science teacher, my students will derive scientific evidence from instructional materials such as a textbook.	5	4	3	2	1
30. As a science teacher, I will be able to encourage students to gather the appropriate data necessary for answering their questions.	5	4	3	2	1
31. As a teacher of science, I will be able to offer/model approaches for generating explanations from evidence.	5	4	3	2	1
32. I will be able to coach students in the clear articulation of explanations.	5	4	3	2	1
33. Through the process of sharing explanations, I will be able to provide students with the opportunity to critique explanations and investigation methods.	5	4	3	2	1
34. As a science teacher, I will require students to create scientific claims based on observational evidence.	5	4	3	2	1
35. As a teacher of science, I will expect my students to think about other reasonable explanations that can be derived from the evidence presented.	5	4	3	2	1
36. I will be able to facilitate open-ended, long-term student investigations in an attempt to provide opportunities for students to gather evidence.	5	4	3	2	1
37. I will be able to help students refine questions posed by the teacher or instructional materials, so they can experience both interesting and productive investigations.	5	4	3	2	1
38. As a science teacher, I will be able to provide demonstrations through which students can focus their queries into manageable questions for investigation.	5	4	3	2	1

	Strongly Agree			Strongly Disagree	
39. As a science teacher, I will require students to develop explanations using evidence.	5	4	3	2	1
40. As a science teacher, I will be able to utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process.	5	4	3	2	1
41. When I am a science teacher, my students will refine their explanations using possible connections to scientific knowledge that have been provided.	5	4	3	2	1
42. As a teacher of science, I will be able to model for my students prescribed steps or procedures for communicating scientific results to the class.	5	4	3	2	1
43. As the science teacher, I will be able to provide my students with possible connections to scientific knowledge through which they can relate their explanations.	5	4	3	2	1
44. As a science teacher, I will be able to provide my students with evidence to be analyzed.	5	4	3	2	1
45. When I am a science teacher, my students will engage in questions I have provided them.	5	4	3	2	1
46. When I am a science teacher, my students will engage in questions that are provided by a variety of sources such as the textbook.	5	4	3	2	1
47. When I am a teacher of science, my students will analyze data that has been supplied, while following teacher instruction.	5	4	3	2	1
48. As a science teacher, I will expect my students to clarify the questions provided in an attempt to enhance science learning.	5	4	3	2	1
49. As a teacher of science, I will be able to provide my students with the data needed to support an investigation.	5	4	3	2	1

	Strongly Agree			Strongly Disagree	
50. When I am a science teacher, my students will communicate and justify their explanations to the class using broad guidelines that have been provided.	5	4	3	2	1
51. When I begin a science unit of study, my students will choose the questions they would like to investigate from a list provided.	5	4	3	2	1
52. When I am a science teacher, my students will analyze teacher provided data in a particular manner.	5	4	3	2	1
53. When I am a science teacher, my students will form their explanations using evidence that has been provided.	5	4	3	2	1
54. As a science teacher, I will be able to provide my students with all evidence required to form explanations through the use of lecture and textbook readings.	5	4	3	2	1
55. When I am a science teacher, my students will construct explanations from evidence using a framework I have provided.	5	4	3	2	1
56. As a science teacher, I will expect my students to follow predetermined procedures when justifying their explanations.	5	4	3	2	1
57. When I am a science teacher, my students will determine what evidence will be most useful for answering their scientific question(s).	5	4	3	2	1
58. When I am a teacher of science, my students will design their own investigations and gather the evidence necessary to answer a particular question.	5	4	3	2	1
59. As a science teacher, I will expect my students to collaborate with me in an attempt to construct criteria for sharing and critiquing explanations.	5	4	3	2	1
60. When I am a teacher of science, my students will share and critique explanations while utilizing broad guidelines that have been provided.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
61. As a teacher of science, I will expect students to use internet based resources or other materials to further develop their investigations.	5	4	3	2	1
62. As a teacher of science, I will be able to model for my students the guidelines to be followed when sharing and critiquing explanations.	5	4	3	2	1
63. As a science teacher, I will be able to instruct students to independently evaluate the consistency between their own explanations and scientifically accepted ideas.	5	4	3	2	1
64. As a science teacher, I will expect my students to negotiate with me, the criteria for sharing and critiquing explanations.	5	4	3	2	1
65. As a science teacher, I will be able construct with students the guidelines for communicating results and explanations.	5	4	3	2	1
66. As a science teacher, I will expect my students to refine questions that have been provided.	5	4	3	2	1
67. As a teacher of science, I will be able to provide my students with explanations.	5	4	3	2	1
68. When I am a science teacher, I will expect my students to justify explanations using given steps and procedures.	5	4	3	2	1
69. When I am a science teacher, my students will comprehend teacher presented explanations.	5	4	3	2	1

Appendix K

Self-Efficacy Beliefs in Regard to Inquiry Science Teaching—Version 8

Student Number: ______________________ **Circle One:** Male Female

Please indicate the degree to which you agree or disagree with each statement below by circling in the appropriate number as indicated below.

5	=	Strongly Agree
4	=	Agree
3	=	Uncertain
2	=	Disagree
1	=	Strongly Disagree

When I teach science…	**Strongly Agree**				**Strongly Disagree**
1. I will be able to offer multiple suggestions for creating explanations from data.	5	4	3	2	1
2. I will be able to provide students with the opportunity to construct alternative explanations for the same observations.	5	4	3	2	1
3. I will be able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.	5	4	3	2	1
4. I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students.	5	4	3	2	1
5. I have the necessary skills to determine the best manner through which children can obtain scientific evidence.	5	4	3	2	1
6. I will require students to defend their newly acquired knowledge during large and/or small group discussions.	5	4	3	2	1
7. My students will select among a list of given questions while investigating scientific phenomena.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
When I teach science… 8. I will provide opportunities through which children will obtain evidence from observations and measurements.	5	4	3	2	1
9. I will expect my students to make the results of their investigations public.	5	4	3	2	1
10. I will be able to provide opportunities for students to become the critical decision makers when evaluating the validity of scientific explanations.	5	4	3	2	1
11. I will be able to guide students in asking scientific questions that are meaningful.	5	4	3	2	1
12. I will be able to provide opportunities for my students to describe their investigations and findings to others using their evidence to justify explanations and how data was collected.	5	4	3	2	1
13. I will create (plan) investigations through which students will be expected to gather particular evidence.	5	4	3	2	1
14. I will be able to negotiate with students possible connections between/among explanations.	5	4	3	2	1
15. I will expect students to independently develop explanations using what they already know about scientifically accepted ideas.	5	4	3	2	1
16. I encompass the ability to encourage students to review and ask questions about the results of other students' work.	5	4	3	2	1
17. I will be able to guide students toward appropriate investigations depending on the questions they are attempting to answer.	5	4	3	2	1
18. I will be able to create the majority of the scientific questions needed for students to investigate.	5	4	3	2	1
19. I possess the ability to allow students to devise their own problems to investigate.	5	4	3	2	1

When I teach science…	Strongly Agree				Strongly Disagree
20. My students will make use of data in order to develop explanations as a result of teacher guidance.	5	4	3	2	1
21. I will be able to play the primary role in guiding the identification of scientific questions.	5	4	3	2	1
22. I will be able to guide students toward scientifically accepted ideas upon which they can develop more meaningful understandings of science.	5	4	3	2	1
23. I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations.	5	4	3	2	1
24. I will expect students to recognize the connections existing between proposed explanations and scientific knowledge.	5	4	3	2	1
25. I will expect students to ask scientific questions.	5	4	3	2	1
26. I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence.	5	4	3	2	1
27. My students will investigate questions I have developed.	5	4	3	2	1
28. My students will create scientific explanations based on evidence, as a result of teacher assistance.	5	4	3	2	1
29. My students will derive scientific evidence from instructional materials such as a textbook.	5	4	3	2	1
30. I will be able to encourage students to gather the appropriate data necessary for answering their questions.	5	4	3	2	1
31. I will be able to offer/model approaches for generating explanations from evidence.	5	4	3	2	1
32. I will be able to coach students in the clear articulation of explanations.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
When I teach science…					
33. Through the process of sharing explanations, I will be able to provide students with the opportunity to critique explanations and investigation methods.	5	4	3	2	1
34. I will require students to create scientific claims based on observational evidence.	5	4	3	2	1
35. I will expect my students to think about otherreasonable explanations that can be derived from the evidence presented.	5	4	3	2	1
36. I will be able to facilitate open-ended, long-term student investigations in an attempt to provide opportunities for students to gather evidence.	5	4	3	2	1
37. I will be able to help students refine questions posed by the teacher or instructional materials, so they can experience both interesting and productive investigations.	5	4	3	2	1
38. I will be able to provide demonstrations through which students can focus their queries into manageable questions for investigation.	5	4	3	2	1
39. I will require students to develop explanations using evidence.	5	4	3	2	1
40. I will be able to utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process.	5	4	3	2	1
41. My students will refine their explanations using possible connections to scientific knowledge that have been provided.	5	4	3	2	1
42. I will be able to model for my students prescribed steps or procedures for communicating scientific results to the class.	5	4	3	2	1
43. I will be able to provide my students with possible connections to scientific knowledge through which they can relate their explanations.	5	4	3	2	1
44. I will be able to provide my students with evidence to be analyzed.	5	4	3	2	1

When I teach science…	Strongly Agree				Strongly Disagree
45. My students will engage in questions I have provided them.	5	4	3	2	1
46. My students will engage in questions that are provided by a variety of sources such as the textbook.	5	4	3	2	1
47. My students will analyze data that has been supplied, while following teacher instruction.	5	4	3	2	1
48. I will expect my students to clarify the questions provided in an attempt to enhance science learning.	5	4	3	2	1
49. I will be able to provide my students with the data needed to support an investigation.	5	4	3	2	1
50. My students will communicate and justify their explanations to the class using broad guidelines that have been provided.	5	4	3	2	1
51. My students will choose the questions they would like to investigate from a list provided.	5	4	3	2	1
52. My students will analyze teacher provided data in a particular manner.	5	4	3	2	1
53. My students will form their explanations using evidence that has been provided.	5	4	3	2	1
54. I will be able to provide my students with all evidence required to form explanations through the use of lecture and textbook readings.	5	4	3	2	1
55. My students will construct explanations from evidence using a framework I have provided.	5	4	3	2	1
56. I will expect my students to follow predetermined procedures when justifying their explanations.	5	4	3	2	1
57. My students will determine what evidence will be most useful for answering their scientific question(s).	5	4	3	2	1
58. My students will design their own investigations and gather the evidence necessary to answer a particular question.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
When I teach science…					
59. I will expect my students to collaborate with me in an attempt to construct criteria for sharing and critiquing explanations.	5	4	3	2	1
60. My students will share and critique explanations while utilizing broad guidelines that have been provided.	5	4	3	2	1
61. I will expect students to use internet based resources or other materials to further develop their investigations.	5	4	3	2	1
62. I will be able to model for my students the guidelines to be followed when sharing and critiquing explanations.	5	4	3	2	1
63. I will be able to instruct students to independently evaluate the consistency between their own explanations and scientifically accepted ideas.	5	4	3	2	1
64. I will expect my students to negotiate with me the criteria for sharing and critiquing explanations.	5	4	3	2	1
65. I will be able construct with students the guidelines for communicating results and explanations.	5	4	3	2	1
66. I will expect my students to refine questions that have been provided.	5	4	3	2	1
67. I will be able to provide my students with explanations.	5	4	3	2	1
68. I will expect my students to justify explanations using given steps and procedures.	5	4	3	2	1
69. My students will comprehend teacher presented explanations.	5	4	3	2	1

Appendix L

ANOVA Results by Gender

L.1. Summary Descriptive Statistics for Self-Efficacy (SE) and Outcome Expectancy (OE) by Gender – Version 7

						95% Confidence Interval for Mean			
		N	**Mean**	**Std. Deviation**	**Std. Error**	**Lower Bound**	**Upper Bound**	**Minimum**	**Maximum**
SE1	M	17	24.1597	2.82928	.68620	22.7050	25.6143	17.43	29.57
	F	168	23.0085	3.02261	.23320	22.5481	23.4689	13.29	30.71
	Total	185	23.1143	3.01651	.22178	22.6767	23.5518	13.29	30.71
OE1	M	18	25.4514	4.79586	1.13039	23.0665	27.8363	12.13	30.50
	F	168	25.0543	3.55166	.27402	24.5133	25.5953	13.25	32.63
	Total	186	25.0927	3.67618	.26955	24.5610	25.6245	12.13	32.63
SE2	M	18	26.9514	3.41470	.80485	25.2533	28.6495	21.25	33.25
	F	169	25.8595	3.19339	.24565	25.3745	26.3444	16.50	34.50
	Total	187	25.9646	3.22194	.23561	25.4998	26.4294	16.50	34.50
OE2	M	18	26.3750	3.86205	.91029	24.4544	28.2956	20.13	31.63
	F	170	25.5699	2.99901	.23001	25.1158	26.0239	16.25	33.38
	Total	188	25.6469	3.08880	.22527	25.2025	26.0913	16.25	33.38
SE3	M	17	20.8235	2.13882	.51874	19.7238	21.9232	16.83	23.83
	F	168	19.9464	2.22281	.17149	19.6079	20.2850	13.50	25.83
	Total	185	20.0270	2.22412	.16352	19.7044	20.3496	13.50	25.83
OE3	M	18	23.4444	2.27037	.53513	22.3154	24.5735	19.71	27.57
	F	171	22.8647	2.71439	.20757	22.4549	23.2744	10.29	29.71
	Total	189	22.9199	2.67538	.19461	22.5360	23.3038	10.29	29.71
SE4	M	18	20.3704	1.92469	.45365	19.4132	21.3275	16.50	23.83
	F	169	20.0207	2.43671	.18744	19.6507	20.3908	13.17	25.83
	Total	187	20.0544	2.39003	.17478	19.7096	20.3992	13.17	25.83
OE4	M	18	12.4444	1.25310	.29536	11.8213	13.0676	10.00	14.50
	F	171	12.7588	1.63034	.12468	12.5127	13.0049	6.25	16.25
	Total	189	12.7288	1.59815	.11625	12.4995	12.9582	6.25	16.25
SE5	M	18	24.6270	2.80033	.66005	23.2344	26.0196	18.29	29.71
	F	169	24.6974	2.85909	.21993	24.2632	25.1316	11.43	30.71
	Total	187	24.6906	2.84614	.20813	24.2800	25.1012	11.43	30.71
OE5	M	18	23.9028	2.21855	.52292	22.7995	25.0060	20.25	27.50
	F	167	25.4588	3.13076	.24227	24.9805	25.9372	15.38	35.63
	Total	185	25.3074	3.08405	.22674	24.8601	25.7548	15.38	35.63

L.2. Summary Descriptive Statistics for Self-Efficacy (SE) and Outcome Expectancy (OE) by Gender – Version 8

						95% Confidence Interval for Mean			
		N	**Mean**	**Std. Deviation**	**Std. Error**	**Lower Bound**	**Upper Bound**	**Minimum**	**Maximum**
SE1	M	19	24.3910	2.50118	.57381	23.1854	25.5965	18.57	28.71
	F	165	24.4814	2.57400	.20039	24.0857	24.8771	18.43	30.71
	Total	184	24.4720	2.56002	.18873	24.0997	24.8444	18.43	30.71
OE1	M	19	27.2237	3.17176	.72765	25.6949	28.7524	20.25	32.38
	F	163	27.0445	3.87462	.30348	26.4452	27.6438	15.13	35.38
	Total	182	27.0632	3.80003	.28168	26.5074	27.6190	15.13	35.38
SE2	M	19	28.4737	2.52817	.58000	27.2551	29.6922	24.25	34.63
	F	162	28.0386	3.08092	.24206	27.5606	28.5166	19.25	34.50
	Total	181	28.0843	3.02443	.22480	27.6407	28.5278	19.25	34.63
OE2	M	19	27.9408	3.39407	.77865	26.3049	29.5767	20.25	33.50
	F	162	26.9491	3.21558	.25264	26.4502	27.4480	19.25	34.63
	Total	181	27.0532	3.23936	.24078	26.5781	27.5283	19.25	34.63
SE3	M	19	20.8158	2.38494	.54714	19.6663	21.9653	14.33	24.50
	F	164	21.0762	2.24727	.17548	20.7297	21.4227	14.67	25.83
	Total	183	21.0492	2.25652	.16681	20.7201	21.3783	14.33	25.83
OE3	M	18	24.1667	2.74889	.64792	22.7997	25.5337	18.71	28.71
	F	161	24.6016	2.83880	.22373	24.1598	25.0434	14.29	30.71
	Total	179	24.5579	2.82537	.21118	24.1411	24.9746	14.29	30.71
SE4	M	19	20.6579	2.90618	.66672	19.2572	22.0586	13.50	25.83
	F	164	21.0569	2.29396	.17913	20.7032	21.4106	14.50	25.83
	Total	183	21.0155	2.35862	.17435	20.6715	21.3595	13.50	25.83
OE4	M	19	13.5658	1.64114	.37650	12.7748	14.3568	9.00	16.25
	F	164	13.2226	1.75711	.13721	12.9516	13.4935	6.00	16.25
	Total	183	13.2582	1.74428	.12894	13.0038	13.5126	6.00	16.25
SE5	M	19	24.9098	3.73080	.85590	23.1116	26.7080	15.43	30.71
	F	164	25.6272	2.66146	.20783	25.2168	26.0376	15.43	30.71
	Total	183	25.5527	2.78723	.20604	25.1462	25.9592	15.43	30.71
OE5	M	19	28.3684	3.37821	.77501	26.7402	29.9967	17.25	32.50
	F	162	27.0926	3.23829	.25442	26.5902	27.5950	17.38	34.63
	Total	181	27.2265	3.26720	.24285	26.7473	27.7057	17.25	34.63

L.3. Analysis of Variance Results for Self-Efficacy (SE) and Outcome Expectancy (OE) by Gender – Version 7

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
SE1	Between Groups	20.458	1	20.458	2.264	.134
	Within Groups	1653.820	183	9.037		
	Total	1674.278	184			
OE1	Between Groups	2.563	1	2.563	.189	.664
	Within Groups	2497.587	184	13.574		
	Total	2500.150	185			
SE2	Between Groups	19.395	1	19.395	1.877	.172
	Within Groups	1911.448	185	10.332		
	Total	1930.843	186			
OE2	Between Groups	10.551	1	10.551	1.107	.294
	Within Groups	1773.561	186	9.535		
	Total	1784.113	187			
SE3	Between Groups	11.876	1	11.876	2.419	.122
	Within Groups	898.322	183	4.909		
	Total	910.198	184			
OE3	Between Groups	5.474	1	5.474	.764	.383
	Within Groups	1340.169	187	7.167		
	Total	1345.644	188			
SE4	Between Groups	1.989	1	1.989	.347	.557
	Within Groups	1060.486	185	5.732		
	Total	1062.475	186			
OE4	Between Groups	1.609	1	1.609	.629	.429
	Within Groups	478.556	187	2.559		
	Total	480.165	188			
SE5	Between Groups	.081	1	.081	.010	.921
	Within Groups	1506.610	185	8.144		
	Total	1506.691	186			
OE5	Between Groups	39.343	1	39.343	4.209	.042
	Within Groups	1710.750	183	9.348		
	Total	1750.093	184			

L.4. Analysis of Variance Results for Self-Efficacy (SE) and Outcome Expectancy (OE) by Gender – Version 8

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
SE1	Between Groups	.139	1	.139	.021	.885
	Within Groups	1199.186	182	6.589		
	Total	1199.326	183			
OE1	Between Groups	.546	1	.546	.038	.846
	Within Groups	2613.133	180	14.517		
	Total	2613.680	181			
SE2	Between Groups	3.219	1	3.219	.351	.554
	Within Groups	1643.277	179	9.180		
	Total	1646.496	180			
OE2	Between Groups	16.725	1	16.725	1.599	.208
	Within Groups	1872.091	179	10.459		
	Total	1888.816	180			
SE3	Between Groups	1.155	1	1.155	.226	.635
	Within Groups	925.569	181	5.114		
	Total	926.724	182			
OE3	Between Groups	3.063	1	3.063	.382	.537
	Within Groups	1417.864	177	8.011		
	Total	1420.926	178			
SE4	Between Groups	2.711	1	2.711	.486	.487
	Within Groups	1009.773	181	5.579		
	Total	1012.484	182			
OE4	Between Groups	2.006	1	2.006	.658	.418
	Within Groups	551.732	181	3.048		
	Total	553.738	182			
SE5	Between Groups	8.763	1	8.763	1.129	.289
	Within Groups	1405.132	181	7.763		
	Total	1413.895	182			
OE5	Between Groups	27.681	1	27.681	2.616	.108
	Within Groups	1893.751	179	10.580		
	Total	1921.431	180			

Appendix M

ANOVA Results by Section

M.1. Summary Descriptive Statistics for Self-Efficacy (SE) and Outcome Expectancy (OE) by Section – Version 7

						95% Confidence Interval for Mean			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
SE1	0	42	22.4932	2.75537	.42516	21.6346	23.3518	18.29	29.71
	1	27	23.8889	3.37256	.64905	22.5547	25.2230	13.29	29.57
	2	30	21.4667	2.98387	.54478	20.3525	22.5809	16.29	29.57
	3	28	22.5561	2.70559	.51131	21.5070	23.6052	16.43	28.43
	4	30	24.9048	2.35168	.42936	24.0266	25.7829	20.71	30.71
	5	28	23.7041	2.87111	.54259	22.5908	24.8174	19.14	29.57
	Total	185	23.1143	3.01651	.22178	22.6767	23.5518	13.29	30.71
OE1	0	41	24.1860	3.54305	.55333	23.0677	25.3043	16.38	31.38
	1	29	25.9181	3.58464	.66565	24.5546	27.2816	13.25	30.50
	2	30	23.6792	3.40158	.62104	22.4090	24.9493	16.38	31.63
	3	27	26.7454	2.56841	.49429	25.7293	27.7614	21.50	32.50
	4	30	24.8500	4.36611	.79714	23.2197	26.4803	12.13	32.50
	5	29	25.7241	3.67353	.68216	24.3268	27.1215	14.38	32.63
	Total	186	25.0927	3.67618	.26955	24.5610	25.6245	12.13	32.63
SE2	0	40	24.9500	3.19828	.50569	23.9271	25.9729	20.13	34.25
	1	30	26.9042	3.23732	.59105	25.6953	28.1130	16.50	32.50
	2	31	24.2218	3.62568	.65119	22.8919	25.5517	18.25	34.38
	3	27	25.9537	2.59209	.49885	24.9283	26.9791	20.25	32.50
	4	30	27.4125	2.86047	.52225	26.3444	28.4806	22.13	34.50
	5	29	26.7672	2.52305	.46852	25.8075	27.7270	23.13	31.50
	Total	187	25.9646	3.22194	.23561	25.4998	26.4294	16.50	34.50
OE2	0	42	24.5625	2.87059	.44294	23.6680	25.4570	19.13	30.38
	1	30	26.4208	2.94297	.53731	25.3219	27.5198	16.25	31.50
	2	30	24.2625	3.24657	.59274	23.0502	25.4748	18.25	31.63
	3	27	26.7731	2.22233	.42769	25.8940	27.6523	21.38	31.50
	4	30	26.1042	3.43145	.62649	24.8228	27.3855	20.13	31.50
	5	29	26.3276	2.93216	.54449	25.2123	27.4429	21.38	33.38
	Total	188	25.6469	3.08880	.22527	25.2025	26.0913	16.25	33.38

SE3	0	40	20.1583	1.98963	.31459	19.5220	20.7946	15.50	24.83
	1	29	19.9483	2.29047	.42533	19.0770	20.8195	14.50	23.83
	2	31	18.6452	2.11509	.37988	17.8693	19.4210	14.67	23.67
	3	26	19.2628	2.15002	.42165	18.3944	20.1312	13.50	22.83
	4	30	21.2222	2.15462	.39338	20.4177	22.0268	16.50	25.83
	5	29	20.8506	1.76009	.32684	20.1811	21.5201	17.67	24.83
	Total	185	20.0270	2.22412	.16352	19.7044	20.3496	13.50	25.83
OE3	0	42	22.3605	2.14929	.33164	21.6908	23.0303	18.29	28.71
	1	30	23.2095	3.19741	.58376	22.0156	24.4035	10.29	26.71
	2	31	21.5853	2.95944	.53153	20.4997	22.6708	14.43	27.71
	3	27	23.0370	2.28901	.44052	22.1315	23.9425	18.57	29.57
	4	30	24.0810	2.69508	.49205	23.0746	25.0873	18.57	29.71
	5	29	23.5468	2.13026	.39558	22.7365	24.3571	18.71	26.57
	Total	189	22.9199	2.67538	.19461	22.5360	23.3038	10.29	29.71
SE4	0	41	20.0935	2.39822	.37454	19.3365	20.8505	15.50	25.83
	1	30	20.4944	2.00549	.36615	19.7456	21.2433	13.17	23.67
	2	30	18.6833	2.46366	.44980	17.7634	19.6033	13.67	24.67
	3	27	19.3889	2.03127	.39092	18.5853	20.1924	15.50	23.83
	4	30	21.7056	2.39559	.43737	20.8110	22.6001	17.33	25.83
	5	29	19.8736	1.97386	.36654	19.1227	20.6244	16.50	22.67
	Total	187	20.0544	2.39003	.17478	19.7096	20.3992	13.17	25.83
OE4	0	42	12.2381	1.46187	.22557	11.7825	12.6936	9.00	15.75
	1	30	12.9250	1.76062	.32144	12.2676	13.5824	6.25	15.00
	2	31	12.3065	1.44440	.25942	11.7766	12.8363	8.75	15.00
	3	27	12.4537	1.59633	.30721	11.8222	13.0852	8.75	15.00
	4	30	13.5583	1.54346	.28180	12.9820	14.1347	11.50	16.25
	5	29	13.0862	1.48245	.27528	12.5223	13.6501	9.00	16.25
	Total	189	12.7288	1.59815	.11625	12.4995	12.9582	6.25	16.25
SE5	0	41	24.4808	2.83990	.44352	23.5845	25.3772	19.43	29.71
	1	30	24.9048	3.25426	.59414	23.6896	26.1199	11.43	29.57
	2	30	23.5952	2.82944	.51658	22.5387	24.6518	19.43	29.71
	3	27	24.2275	2.22807	.42879	23.3461	25.1089	20.43	29.71
	4	30	25.7714	2.98238	.54451	24.6578	26.8851	18.29	30.71
	5	29	25.2118	2.46332	.45743	24.2748	26.1488	18.29	30.71
	Total	187	24.6906	2.84614	.20813	24.2800	25.1012	11.43	30.71
OE5	0	41	24.9756	2.87272	.44864	24.0689	25.8824	20.25	33.63
	1	28	25.6071	2.10811	.39839	24.7897	26.4246	21.25	29.50
	2	31	24.3427	3.13298	.56270	23.1936	25.4919	15.38	31.50
	3	27	25.6435	3.39749	.65385	24.2995	26.9875	18.50	33.50
	4	29	25.8664	3.61991	.67220	24.4894	27.2433	19.50	35.63
	5	29	25.6466	3.20262	.59471	24.4283	26.8648	20.38	32.38
	Total	185	25.3074	3.08405	.22674	24.8601	25.7548	15.38	35.63

M.2. Summary Descriptive Statistics for Self-Efficacy (SE) and Outcome Expectancy (OE) by Section – Version 8

						95% Confidence Interval for Mean			
		N	**Mean**	**Std. Deviation**	**Std. Error**	**Lower Bound**	**Upper Bound**	**Minimum**	**Maximum**
SE1	0	38	24.4699	2.19283	.35572	23.7492	25.1907	20.29	29.71
	1	30	24.4714	2.73125	.49866	23.4516	25.4913	18.57	28.71
	2	29	25.0739	2.34447	.43536	24.1821	25.9657	21.29	30.57
	3	27	24.1429	2.67173	.51417	23.0860	25.1998	18.43	29.71
	4	31	24.2995	2.51617	.45192	23.3766	25.2225	19.29	28.71
	5	29	24.3645	3.05288	.56691	23.2033	25.5258	18.57	30.71
	Total	184	24.4720	2.56002	.18873	24.0997	24.8444	18.43	30.71
OE1	0	36	26.3333	3.68685	.61447	25.0859	27.5808	17.25	33.50
	1	30	27.9125	3.09357	.56481	26.7573	29.0677	20.38	33.38
	2	29	26.2586	4.25511	.79015	24.6401	27.8772	15.13	32.63
	3	27	28.0694	4.04205	.77789	26.4705	29.6684	20.25	33.63
	4	31	26.7097	4.08878	.73437	25.2099	28.2095	17.25	32.63
	5	29	27.3362	3.45444	.64147	26.0222	28.6502	18.38	35.38
	Total	182	27.0632	3.80003	.28168	26.5074	27.6190	15.13	35.38
SE2	0	36	27.7361	3.12818	.52136	26.6777	28.7945	20.25	33.38
	1	30	28.3625	2.24960	.41072	27.5225	29.2025	23.38	33.50
	2	29	28.1379	3.45755	.64205	26.8228	29.4531	19.25	34.63
	3	27	27.6435	3.03915	.58488	26.4413	28.8458	21.25	33.63
	4	30	28.1750	3.01498	.55046	27.0492	29.3008	22.38	32.63
	5	29	28.4914	3.28245	.60954	27.2428	29.7400	22.25	34.50
	Total	181	28.0843	3.02443	.22480	27.6407	28.5278	19.25	34.63
OE2	0	38	26.3849	3.32862	.53997	25.2908	27.4790	20.38	32.50
	1	30	27.9833	2.84111	.51871	26.9224	29.0442	21.25	34.63
	2	29	26.3793	3.60021	.66854	25.0099	27.7488	19.25	33.50
	3	27	26.6574	2.93614	.56506	25.4959	27.8189	20.25	31.50
	4	30	27.4125	3.49956	.63893	26.1057	28.7193	20.25	33.38
	5	27	27.6806	2.95953	.56956	26.5098	28.8513	20.38	33.50
	Total	181	27.0532	3.23936	.24078	26.5781	27.5283	19.25	34.63
SE3	0	38	21.4693	2.12162	.34417	20.7719	22.1667	17.50	25.83
	1	30	20.6389	2.43147	.44392	19.7310	21.5468	14.33	24.67
	2	29	21.2069	2.15549	.40026	20.3870	22.0268	16.33	25.83
	3	27	21.1235	2.15856	.41542	20.2696	21.9774	17.67	25.83
	4	31	20.1667	2.25051	.40420	19.3412	20.9922	15.50	24.67
	5	28	21.6607	2.26327	.42772	20.7831	22.5383	14.67	25.83
	Total	183	21.0492	2.25652	.16681	20.7201	21.3783	14.33	25.83

OE3	0	37	24.9730	2.45961	.40436	24.1529	25.7930	18.29	30.71
	1	30	24.7095	2.62036	.47841	23.7311	25.6880	20.14	29.71
	2	28	24.4082	3.76315	.71117	22.9490	25.8674	14.29	30.57
	3	27	23.9841	2.87312	.55293	22.8476	25.1207	19.43	29.71
	4	30	24.0762	2.82637	.51602	23.0208	25.1316	18.29	28.71
	5	27	25.0847	2.35615	.45344	24.1526	26.0167	20.57	28.57
	Total	179	24.5579	2.82537	.21118	24.1411	24.9746	14.29	30.71
SE4	0	38	21.2939	2.14085	.34729	20.5902	21.9975	17.50	25.83
	1	38	24.4699	2.19283	.35572	23.7492	25.1907	20.29	29.71
	2	30	24.4714	2.73125	.49866	23.4516	25.4913	18.57	28.71
	3	29	25.0739	2.34447	.43536	24.1821	25.9657	21.29	30.57
	4	27	24.1429	2.67173	.51417	23.0860	25.1998	18.43	29.71
	5	31	24.2995	2.51617	.45192	23.3766	25.2225	19.29	28.71
	Total	29	24.3645	3.05288	.56691	23.2033	25.5258	18.57	30.71
OE4	0	184	24.4720	2.56002	.18873	24.0997	24.8444	18.43	30.71
	1	36	26.3333	3.68685	.61447	25.0859	27.5808	17.25	33.50
	2	30	27.9125	3.09357	.56481	26.7573	29.0677	20.38	33.38
	3	29	26.2586	4.25511	.79015	24.6401	27.8772	15.13	32.63
	4	27	28.0694	4.04205	.77789	26.4705	29.6684	20.25	33.63
	5	31	26.7097	4.08878	.73437	25.2099	28.2095	17.25	32.63
	Total	29	27.3362	3.45444	.64147	26.0222	28.6502	18.38	35.38
SE5	0	182	27.0632	3.80003	.28168	26.5074	27.6190	15.13	35.38
	1	36	27.7361	3.12818	.52136	26.6777	28.7945	20.25	33.38
	2	30	28.3625	2.24960	.41072	27.5225	29.2025	23.38	33.50
	3	29	28.1379	3.45755	.64205	26.8228	29.4531	19.25	34.63
	4	27	27.6435	3.03915	.58488	26.4413	28.8458	21.25	33.63
	5	30	28.1750	3.01498	.55046	27.0492	29.3008	22.38	32.63
	Total	29	28.4914	3.28245	.60954	27.2428	29.7400	22.25	34.50
OE5	0	181	28.0843	3.02443	.22480	27.6407	28.5278	19.25	34.63
	1	38	26.3849	3.32862	.53997	25.2908	27.4790	20.38	32.50
	2	30	27.9833	2.84111	.51871	26.9224	29.0442	21.25	34.63
	3	29	26.3793	3.60021	.66854	25.0099	27.7488	19.25	33.50
	4	27	26.6574	2.93614	.56506	25.4959	27.8189	20.25	31.50
	5	30	27.4125	3.49956	.63893	26.1057	28.7193	20.25	33.38
	Total	27	27.6806	2.95953	.56956	26.5098	28.8513	20.38	33.50

M.3. Analysis of Variance Results Self Efficacy (SE) and Outcome Expectancy (OE) by Section – Version 7

		Sum of Squares	df	Mean Square	F	Sig.
SE1	Between Groups	228.479	5	45.696	5.657	.000
	Within Groups	1445.799	179	8.077		
	Total	1674.278	184			
OE1	Between Groups	200.483	5	40.097	3.138	.010
	Within Groups	2299.667	180	12.776		
	Total	2500.150	185			
SE2	Between Groups	243.399	5	48.680	5.222	.000
	Within Groups	1687.444	181	9.323		
	Total	1930.843	186			
OE2	Between Groups	178.812	5	35.762	4.055	.002
	Within Groups	1605.301	182	8.820		
	Total	1784.113	187			
SE3	Between Groups	137.773	5	27.555	6.385	.000
	Within Groups	772.425	179	4.315		
	Total	910.198	184			
OE3	Between Groups	123.086	5	24.617	3.685	.003
	Within Groups	1222.558	183	6.681		
	Total	1345.644	188			
SE4	Between Groups	156.963	5	31.393	6.275	.000
	Within Groups	905.512	181	5.003		
	Total	1062.475	186			
OE4	Between Groups	43.189	5	8.638	3.617	.004
	Within Groups	436.976	183	2.388		
	Total	480.165	188			

SE5	Between Groups	87.889	5	17.578	2.242	.052
	Within Groups	1418.802	181	7.839		
	Total	1506.691	186			
OE5	Between Groups	51.324	5	10.265	1.082	.372
	Within Groups	1698.769	179	9.490		
	Total	1750.093	184			

M.4. Analysis of Variance Results Self Efficacy (SE) and Outcome Expectancy (OE) by Section – Version 8

		Sum of Squares	df	Mean Square	F	Sig.
SE1	Between Groups	14.688	5	2.938	.441	.819
	Within Groups	1184.638	178	6.655		
	Total	1199.326	183			
OE1	Between Groups	92.964	5	18.593	1.298	.267
	Within Groups	2520.716	176	14.322		
	Total	2613.680	181			
SE2	Between Groups	17.068	5	3.414	.367	.871
	Within Groups	1629.428	175	9.311		
	Total	1646.496	180			
OE2	Between Groups	74.826	5	14.965	1.444	.211
	Within Groups	1813.990	175	10.366		
	Total	1888.816	180			
SE3	Between Groups	47.242	5	9.448	1.902	.096
	Within Groups	879.482	177	4.969		
	Total	926.724	182			
OE3	Between Groups	31.034	5	6.207	.773	.571
	Within Groups	1389.892	173	8.034		
	Total	1420.926	178			
SE4	Between Groups	20.850	5	4.170	.744	.591
	Within Groups	991.634	177	5.602		
	Total	1012.484	182			

OE4	Between Groups	8.261	5	1.652	.536	.749
	Within Groups	545.477	177	3.082		
	Total	553.738	182			
SE5	Between Groups	69.719	5	13.944	1.836	.108
	Within Groups	1344.176	177	7.594		
	Total	1413.895	182			
OE5	Between Groups	27.393	5	5.479	.506	.771
	Within Groups	1894.039	175	10.823		
	Total	1921.431	180			

Appendix N

Self-Efficacy Beliefs in Regard to Teaching of Science as Inquiry - Final

Student Number: ________________________ Circle One: Male Female

Section Number: ______________________

Please indicate the degree to which you agree or disagree with each statement below by circling in the appropriate number as indicated below.

5	=	Strongly Agree
4	=	Agree
3	=	Uncertain
2	=	Disagree
1	=	Strongly Disagree

When I teach science…	**Strongly Agree**				**Strongly Disagree**
1. I will be able to offer multiple suggestions for creating explanations from data.	5	4	3	2	1
2. I will be able to provide students with the opportunity to construct alternative explanations for the same observations.	5	4	3	2	1
3. I will be able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.	5	4	3	2	1
4. I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students.	5	4	3	2	1
5. I have the necessary skills to determine the best manner through which children can obtain scientific evidence.	5	4	3	2	1
6. I will require students to defend their newly acquired knowledge during large and/or small group discussions.	5	4	3	2	1
7. My students will select among a list of given questions while investigating scientific phenomena.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
When I teach science… 8. I will provide opportunities through which children will obtain evidence from observations and measurements.	5	4	3	2	1
9. I will expect my students to make the results of their investigations public.	5	4	3	2	1
10. I will be able to provide opportunities for students to become the critical decision makers when evaluating the validity of scientific explanations.	5	4	3	2	1
11. I will be able to guide students in asking scientific questions that are meaningful.	5	4	3	2	1
12. I will be able to provide opportunities for my students to describe their investigations and findings to others using their evidence to justify explanations and how data was collected.	5	4	3	2	1
13. I will create (plan) investigations through which students will be expected to gather particular evidence.	5	4	3	2	1
14. I will be able to negotiate with students possible connections between/among explanations.	5	4	3	2	1
15. I will expect students to independently develop explanations using what they already know about scientifically accepted ideas.	5	4	3	2	1
16. I encompass the ability to encourage students to review and ask questions about the results of other students' work.	5	4	3	2	1
17. I will be able to guide students toward appropriate investigations depending on the questions they are attempting to answer.	5	4	3	2	1
18. I will be able to create the majority of the scientific questions needed for students to investigate.	5	4	3	2	1
19. I possess the ability to allow students to devise their own problems to investigate.	5	4	3	2	1

When I teach science…	Strongly Agree				Strongly Disagree
20. My students will make use of data in order to develop explanations as a result of teacher guidance.	5	4	3	2	1
21. I will be able to play the primary role in guiding the identification of scientific questions.	5	4	3	2	1
22. I will be able to guide students toward scientifically accepted ideas upon which they can develop more meaningful understandings of science.	5	4	3	2	1
23. I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations.	5	4	3	2	1
24. I will expect students to recognize the connections existing between proposed explanations and scientific knowledge.	5	4	3	2	1
25. I will expect students to ask scientific questions.	5	4	3	2	1
26. I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence.	5	4	3	2	1
27. My students will investigate questions I have developed.	5	4	3	2	1
28. My students will create scientific explanations based on evidence, as a result of teacher assistance.	5	4	3	2	1
29. My students will derive scientific evidence from instructional materials such as a textbook.	5	4	3	2	1
30. I will be able to encourage students to gather the appropriate data necessary for answering their questions.	5	4	3	2	1
31. I will be able to offer/model approaches for generating explanations from evidence.	5	4	3	2	1
32. I will be able to coach students in the clear articulation of explanations.	5	4	3	2	1

	Strongly Agree				Strongly Disagree
When I teach science…					
33. Through the process of sharing explanations, I will be able to provide students with the opportunity to critique explanations and investigation methods.	5	4	3	2	1
34. I will require students to create scientific claims based on observational evidence.	5	4	3	2	1
35. I will expect my students to think about otherreasonable explanations that can be derived from the evidence presented.	5	4	3	2	1
36. I will be able to facilitate open-ended, long-term student investigations in an attempt to provide opportunities for students to gather evidence.	5	4	3	2	1
37. I will be able to help students refine questions posed by the teacher or instructional materials, so they can experience both interesting and productive investigations.	5	4	3	2	1
38. I will be able to provide demonstrations through which students can focus their queries into manageable questions for investigation.	5	4	3	2	1
39. I will require students to develop explanations using evidence.	5	4	3	2	1
40. I will be able to utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process.	5	4	3	2	1
41. My students will refine their explanations using possible connections to scientific knowledge that have been provided.	5	4	3	2	1
42. I will be able to model for my students prescribed steps or procedures for communicating scientific results to the class.	5	4	3	2	1
43. I will be able to provide my students with possible connections to scientific knowledge through which they can relate their explanations.	5	4	3	2	1
44. I will be able to provide my students with evidence to be analyzed.	5	4	3	2	1

When I teach science…	Strongly Agree				Strongly Disagree
45. My students will engage in questions I have provided them.	5	4	3	2	1
46. My students will engage in questions that are provided by a variety of sources such as the textbook.	5	4	3	2	1
47. My students will analyze data that has been supplied, while following teacher instruction.	5	4	3	2	1
48. I will expect my students to clarify the questions provided in an attempt to enhance science learning.	5	4	3	2	1
49. I will be able to provide my students with the data needed to support an investigation.	5	4	3	2	1
50. My students will communicate and justify their explanations to the class using broad guidelines that have been provided.	5	4	3	2	1
51. My students will choose the questions they would like to investigate from a list provided.	5	4	3	2	1
52. My students will analyze teacher provided data in a particular manner.	5	4	3	2	1
53. My students will form their explanations using evidence that has been provided.	5	4	3	2	1
54. I will be able to provide my students with all evidence required to form explanations through the use of lecture and textbook readings.	5	4	3	2	1
55. My students will construct explanations from evidence using a framework I have provided.	5	4	3	2	1
56. I will expect my students to follow predetermined procedures when justifying their explanations.	5	4	3	2	1
57. My students will determine what evidence will be most useful for answering their scientific question(s).	5	4	3	2	1
58. My students will design their own investigations and gather the evidence necessary to answer a particular question.	5	4	3	2	1

When I teach science…	Strongly Agree				Strongly Disagree
59. I will expect my students to collaborate with me in an attempt to construct criteria for sharing and critiquing explanations.	5	4	3	2	1
60. My students will share and critique explanations while utilizing broad guidelines that have been provided.	5	4	3	2	1
61. I will expect students to use internet based resources or other materials to further develop their investigations.	5	4	3	2	1
62. I will be able to model for my students the guidelines to be followed when sharing and critiquing explanations.	5	4	3	2	1
63. I will be able to instruct students to independently evaluate the consistency between their own explanations and scientifically accepted ideas.	5	4	3	2	1
64. I will expect my students to negotiate with me the criteria for sharing and critiquing explanations.	5	4	3	2	1
65. I will be able construct with students the guidelines for communicating results and explanations.	5	4	3	2	1
66. I will expect my students to refine questions that have been provided.	5	4	3	2	1
67. I will be able to provide my students with explanations.	5	4	3	2	1
68. I will expect my students to justify explanations using given steps and procedures.	5	4	3	2	1
69. My students will comprehend teacher presented explanations.	5	4	3	2	1

Appendix O

Summary Statistics for Gender

O.1. Summary Statistics and Anova Results for Learner Gives Engages in Scientifically Oriented Questions - Self-Efficacy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	17	24.16	2.83	19	24.39	2.50
Female	168	23.01	3.02	165	24.48	2.58

Scale included 7 items with a response scale ranging from 1 (less) ----Amount of Learner Self Direction --- to 5 (more)

O.2. Summary Statistics and Anova Results for Learner Gives Engages in Scientifically Oriented Questions - Outcome Expectancy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	18	25.45	4.80	19	27.22	3.17
Female	168	25.05	3.56	163	27.04	3.87

Scale included 8 items with a response scale ranging from 1 (less) ----Amount of Direction from Teacher or Material--- to 5 (more)

O.3. Summary Statistics and Anova Results for Learner Gives Priority to Evidence in Responding to Questions - Self-Efficacy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	18	26.95	3.41	19	28.47	2.53
Female	169	25.86	3.19	162	28.04	3.08

Scale included 8 items with a response scale ranging from 1 (less) ----Amount of Learner Self Direction --- to 5 (more)

O.4. Summary Statistics and Anova Results for Learner Gives Priority to Evidence in Responding to Questions - Outcome Expectancy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	18	26.38	3.86	19	27.94	3.39
Female	170	25.57	3.00	162	26.95	3.22

Scale included 8 items with a response scale ranging from 1 (less) ----Amount of Direction from Teacher or Material--- to 5 (more)

O.5. Summary Statistics and Anova Results for Learner Formulates Explanations from Evidence - Self-Efficacy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	17	20.82	2.14	19	20.82	2.38
Female	168	19.95	2.22	164	21.08	2.25

Scale included 6 items with a response scale ranging from 1 (less) ----Amount of Learner Self Direction --- to 5 (more)

O.6. Summary Statistics and Anova Results for Learner Formulates Explanations from Evidence - Outcome Expectancy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	18	23.44	2.27	18	24.17	2.75
Female	171	22.86	2.71	161	24.60	2.84

Scale included 7 items with a response scale ranging from 1 (less) ----Amount of Direction from Teacher or Material--- to 5 (more)

O.7. Summary Statistics and Anova Results for Learner Connects Explanations to Scientific Knowledge - Self-Efficacy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	18	20.37	1.92	19	20.66	2.91
Female	169	20.02	2.44	164	21.06	2.29

Scale included 6 items with a response scale ranging from 1 (less) ----Amount of Learner Self Direction --- to 5 (more)

O.8. Summary Statistics and Anova Results for Learner Connects Explanations to Scientific Knowledge - Outcome Expectancy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	18	12.44	1.25	19	13.57	1.64
Female	171	12.76	1.63	164	13.22	1.76

Scale included 4 items with a response scale ranging from 1 (less) ----Amount of Direction from Teacher or Material--- to 5 (more)

O.9. Summary Statistics and Anova Results for Learner Communicates and Justifies Explanations - Self-Efficacy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	18	24.63	2.80	19	24.91	3.73
Female	169	24.70	2.86	164	25.63	2.66

Scale included 7 items with a response scale ranging from 1 (less) ----Amount of Learner Self Direction --- to 5 (more)

O.10. Summary Statistics and Anova Results for Learner Communicates and Justifies Explanations - Outcome Expectancy by Gender

	Version 7			**Version 8**		
Gender	n	Summated Mean	S.D.	n	Summated Mean	S.D
Male	18	23.90	2.22	19	28.37	3.38
Female	167	25.46	3.13	162	27.09	3.24

Scale included 8 items with a response scale ranging from 1 (less) ----Amount of Direction from Teacher or Material--- to 5 (more)

Lori Dira-Smolleck

Education

Ph.D., The Pennsylvania State University, University Park, PA., 2004
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B.S., Indiana University of Pennsylvania, Indiana, PA., 1996

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Graduate Assistant Instructor: The Pennsylvania State University, University Park, PA.

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Publications and Presentations

Dira-Smolleck, L. (April, 2004). Teaching science as inquiry (TSI): The development of an instrument to measure preservice teachers' self-efficacy. Presentation at the National Association for Research in Science Teaching Annual Meeting, Vancouver, British Columbia.

Dira-Smolleck, L. (January, 2004). The development and validation of an instrument to measure preservice teachers' self-efficacy in regard to the teaching of science as inquiry. Presentation at The Association for the Education of Teachers in Science International Conference "Science Education: NCLB: An Opportunity," Nashville, Tennessee.

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