Changes in Preservice Teachers' Self-Efficacy: From Science Methods to Student Teaching

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Abstract

The purpose of this research was to assess preservice teachers self-efficacy at different stages of their educational career in an attempt to determine the extent to which self-efficacy beliefs may change over time. In addition, the critical incidents, which may contribute to changes in self-efficacy, were also investigated. The instrument used in the study was the Teaching Science as Inquiry (TSI) Instrument. The TSI Instrument was administered to 38 preservice elementary teachers to measure the self-efficacy beliefs of the teacher participants in regard to the teaching of science as inquiry. Based on the results and the associated data analysis, mean and median values demonstrate positive change for self-efficacy and outcome expectancy throughout the data collection period.

Keywords: Self-Efficacy, Science education, Inquiry, Teacher education

1. Introduction and Rationale

Teaching science as inquiry is an important theme within educational reform. Although teaching and learning science as inquiry can be challenging, it is attainable and has proven benefits for learning. Specifically, "greater emphasis on inquiry-based teaching is associated with higher science achievement overall" (Von Secker, 2002, p. 159). In addition, "inquiry-based instructional practices are associated with academic excellence, regardless of social context" (Von Secker, 2002, p. 158).

Despite significant evidence to support the effectiveness of inquiry oriented teaching and learning, it has yet to become the widespread practice of elementary science teachers. One explanation for the exclusion of inquiry based teaching and learning can be attributed to the self-efficacy beliefs of teachers. Research indicates that self-efficacy beliefs impact behavior (Morrell, 2003; Bandura, 1977; 1997; Pajaras 1996). "Self-efficacy is also predictive to a willingness to implement innovative teaching strategies and improve methods of instruction" (as cited in Geer, 2007, p. 2).

"Current evidence suggests that teacher efficacy is indeed malleable" (Henson, 2001, p. 21). Therefore, "understanding teachers' beliefs, attitudes and priorities, as well as how they are subject to change in relation to a new intervention, is important to explaining students' and teachers' classroom experience" (Rimm-Kaufman & Sawyer, 2004, p. 322). If science reform is to be successful, we must consider teacher education as one area to begin investigating and potentially increasing the self-efficacy beliefs of teachers. "Preservice teachers must be provided with opportunities to experience success as learners of science in reform-oriented contexts. They themselves must experience first-hand how learning science as inquiry takes place within an elementary school setting" (Smolleck, Zembal-Saul & Yoder, 2006, p. 138). With attention to providing successful experiences, the self-efficacy beliefs of preservice teachers may lead to increased presence of the teaching of science as inquiry in elementary schools. As such, the purpose of this research was to investigate the self-efficacy beliefs of preservice elementary teachers in regard to the teaching of science as inquiry, and how they may change over time. In addition, this study also investigated specific elements of a teacher education program in an attempt to identify the critical incidents most relevant for impacting self-efficacy.

2. Framework

2.1 Inquiry

Inquiry can be defined in a number of ways, however for the purposes of this research, we will be using the description of inquiry outlined in The National Science Education Standards (NRC, 2000). The NRC identifies five Essential Features of Classroom Inquiry that are indicative of the behaviors encapsulated within the teaching and learning of science as inquiry. The five Essential Features include:

1) Learner engages in scientifically oriented questions

2) Learner gives priority to evidence in responding to questions

3) Learner formulates explanations to scientific knowledge

4) Learner connects explanations to scientific knowledge

5) Learner communicates and justifies explanations (p. 29)

These Essential Features are used on a continuum of twenty-four specific variations that explicate the amount of inquiry present within each feature, which ranges from full to partial (NRC, 1996). These features emphasize "that science is the process of gaining knowledge (especially of the natural world), and that gaining knowledge is not the accumulation of facts but the development and enrichment of theories, explanations, and rigorous stories about how the world works" (Drayton & Falk, 2001, p. 26).

The National Science Education Standards (NSES) view scientific inquiry "as an integral component for restructuring science education" (Smolleck, Zembal-Saul & Yoder, 2006).The current shift in science education is from teacher lead instruction to student-centered instruction. The NRC describes inquiry as "a pedagogical method combining higher order questioning with student-centered discussion and discovery of central concepts through laboratory activities" (as cited in Damnjanovic, 1999, p. 71). Hence, teachers encourage students to solve and explain problems through exploration and investigation. "Inquiry-based science involves a restructuring of the classroom, which may entail students working collaboratively, students investigating a research question in a small group and students working beyond the walls of the classroom" (Drayton & Falk, 2000, p. 18).

Inquiry promotes deeper understanding of scientific concepts and phenomena, and as a result is linked with producing positive student outcomes. Specifically, inquiry learning has been found to have positive effects on "cognitive achievement, process skills, and attitude to science…" (Anderson, 2002, p. 4). Furthermore, a "greater emphasis on inquiry-based teaching is associated with higher science achievement overall" (Von Secker, 2002, p. 159). In a study by Scruggs & Mastropieri, students with learning disabilities were found to have significantly higher learning from an inquiry oriented approach (1993). Additional encouraging effect shave been found on outcomes such as scientific literacy, vocabulary knowledge, science processes, critical thinking, conceptual understanding, and attitudes toward science (Haury, 1993).

Although demonstrated benefits for teaching science as inquiry have been documented, inquiry teaching and learning has yet to become consistently infused within elementary science classrooms. One explanation for this exclusion may be found in the self-efficacy beliefs of elementary science teachers.

2.2 Self-efficacy

Self-efficacy is a formidable paradigm that "operates on motivation" (Bandura, 1999, p. 214). The construct of self-efficacy is grounded in social learning theory and as defined by Bandura, consists of two dimensions: personal self-efficacy and outcome expectancy. Personal self-efficacy is defined as "a judgment of one's ability to organize and execute given types of performances" (Bandura, 1997, p. 21). Outcome expectancy on the other hand, relates to an individual's "...judgment of the likely consequences such performances will produce" (p. 21). These two dimensions work together in powerful ways to influence behavior. Specifically, Bandura (1999) notes that self-efficacy impacts the amount of perseverance and effort an individual will undertake when working toward achieving an objective. Self-efficacy influences "the choices individuals make and the courses of action they pursue" (Pajares, 1996, p. 544). Hence, it can be said that higher efficacy leads to …"greater effort, persistence, and resilience" during challenging events (1996, p. 544).

Because of the causal relationship between beliefs and behavior, it is important to recognize the ways in which self-efficacy can be influenced. Specifically, Bandura (1997) identifies four general efficacy building sources as “verbal persuasion”, “vicarious experiences”, “physiological arousal”, and “mastery experiences” (p. 79). The most of significant of the four is mastery experiences because they “provide the most authentic evidence of whether one can muster whatever it takes to succeed” (p. 80). 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, p. 81 - 86). Success with mastery experiences increases self-efficacy beliefs, whereas frequent failures will decrease self-efficacy. In addition, the greater the self-efficacy, the more likely the participant will be to carry on when complications arise (1997).

Other sources of influence on self-efficacy are “vicarious experiences mediated through modeled attainments” (Bandura, 1997, p. 86). Hence, “modeling serves as another effective tool for promoting a sense of personal efficacy” (p. 86). By observing the behaviors of others and the consequences that follow, individuals can decide to imitate, or not to imitate the behaviors. Furthermore, an individual measures their own capability towards a task by observing a model with whom they identify as similar in ability (1997). In general, when an individual observes a person believed to be of similar ability achieve success, this raises the observers’ beliefs in their own efficacy, whereas failures of this similar other, lower the individuals’ beliefs in their own efficacy (1997). “Although vicarious experiences are generally weaker than direct ones, under some conditions vicarious influences can override the impact of direct experience” (Bandura, 1997, p. 88).

Verbal persuasion is another way in which efficacy beliefs can be improved (Bandura, 1997). Verbal persuasion can be “conveyed in ways that undermine a sense of efficacy or boost it” (p. 101). When individuals are told “…that they possess the capabilities to master given tasks, they are likely to mobilize greater effort and sustain it” when faced with adversity (p. 101). The convenience of verbal persuasion allows for widespread use, however, the success verbal persuasion is dependent upon the credibility of those providing the feedback, as well as the way in which it is “framed, structured, and delivered” (Bandura, 1997, p. 102). Although on its own, “verbal persuasion may be limited in power to create enduring increases in perceived efficacy” (Bandura, 1982, p. 127), 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, p. 101).

The fourth principle concept to influence self-efficacy beliefs is physiological and affective states. People often interpret their “physiological activation in stressful situations as signs of vulnerability” (Bandura, 1997, p. 106). Due to the fact that “…high arousal can debilitate performance, people are more inclined to expect success when they are not beset by aversive arousal than if they are tense and viscerally agitated” (p.106). More specifically, when an individual with low self-efficacy experiences a heightened sense of arousal towards a given situation, they are likely to avoid this situation because of the fear and or anxiety they are feeling (1997). On the other hand, it is possible for those with high levels of self-efficacy to find motivation in these arousals and as a result persist with their efforts to achieve goals (1997).

These four concepts have been shown to be important influences for enhancing efficacy. In fact, “current evidence suggests that teacher efficacy is indeed malleable” (Henson, 2001, p. 21). In particular, mastery experiences have a strong bearing on efficacy due to the direct nature of the feedback. As such, this feedback conveys to individuals an indication of adeptness as associated with given situations (Henson, 2001).

2.3 Self-efficacy in Science Education

The relationship between beliefs and behavior can be applied to elementary science teaching and may begin to explain the disconnect between the way science is taught and the way science is actually done. In addition, the influence of self-efficacy may also explain the lack of attention science typically receives in elementary classrooms. “The extent to which teachers will teach science in elementary schools, is influenced by the teachers’ knowledge of science and the issues in teaching science, as well as their feelings or attitudes towards those cognitions” (Watters & Ginns, 1995, p. 2).

Science is taught about one fifth the amount of time as reading and language arts (Fulp, 2002). In fact, only 74% of science teachers view problem solving/inquiry skills as heavily important in their classroom and would consider developing these skills (Weiss, 1994). Because about a quarter of the teachers do not view inquiry teaching as important, it is imperative to try and change these beliefs. As such, the investigation of self-efficacy may help to provide insight into the lack of attention typically placed on science education, particularly in elementary schools. Science experiences in elementary schools need to increase and with a higher self-efficacy in the field, teachers will likely be more willing to increase the amount of time they devote to the teaching of science as inquiry.

Teacher education may have powerful effects on influencing the self-efficacy beliefs of prospective elementary teachers. Hence, this could be an avenue for beginning to ameliorate the low priority that science typically receives in elementary schools. Specifically, research has identified elementary science methods courses and student teaching experiences as potential vehicles for change (Abell & Bryan, 1997; Koballa & French, 1995, Rice & Roychoudhury, 2003). These methods courses and student teaching experiences can be seen as catalysts for overcoming the difficulties pre-service elementary teachers' typically have, such as negative prior experiences with science, as well as ineffective science content courses (2003). As such, this research purports to investigate the ways in which pre-service teacher's self-efficacy beliefs change over time. Furthermore, this study also aims to identify the critical experiences within an elementary science methods course and student teaching experiences that improve or interfere with developing self-efficacy beliefs of pre-service teachers.

3. Methodology

The purpose of this research was to investigate the self-efficacy beliefs of pre-service teachers as well as the extent to which self-efficacy may change over time. In addition, to better understand the construct of self-efficacy, the critical incidents that may contribute to changes in self-efficacy were also investigated. As such, the guiding question for this research was, in what ways can self-efficacy change over time and what are the factors that may influence these changes.

3.1 Participants

Data were collected from 38 pre-service elementary teachers during their junior and senior year at a central Pennsylvania university. During their junior year, the 38 participants were enrolled in a science methods course when data collection took place. Data collection during the senior year for these same 38 participants took place while they were completing their student teaching experiences. Both data collections were conducted within a university classroom setting from 2006 – 2011.

3.2 Instrumentation and Design

This research utilized a mixed method approach. Quantitative data collection included the measurement of the self-efficacy beliefs of the participants using the Teaching Science as Inquiry (TSI) Instrument. The TSI Instrument was developed "based on contemporary ideas about inquiry, as well as grounded in the fundamental ideas of Bandura, particularly the notion of self-efficacy being a context-specific construct" (Smolleck, Zembal-Saul, & Yoder, 2006, p. 141). This instrument, which addresses each of the 24 variations of the essential features of classroom inquiry, was developed for use with pre-service elementary teachers and has been judged to be both valid and reliable for assessing the self-efficacy beliefs of prospective elementary teachers with regard to the teaching of science as inquiry (2006; Dira-Smolleck, 2004). The TSI Instrument addresses "the ideas of where self-efficacy and inquiry science teaching connect" (2006, p. 145). In addition to being situation-specific, the TSI Instrument also took into account Bandura's (1977) notion of self-efficacy being comprised of two constructs: personal self-efficacy and outcome expectancy. This study intended to examine both constructs of self-efficacy as proposed by Bandura. Therefore, the TSI Instrument was an appropriate instrument in this regard.

The TSI Instrument is comprised of a total of 69 items, and represents each of the essential features of classroom inquiry and their variations (National Research Council, 2000). Of these 69 items, 34 items capture the construct of personal self-efficacy and 35 items capture outcome expectancy. Responses for each item on the TSI is recorded using 5 point Likert scale to indicate the degree to which participants agree or disagree with each item (5 = Strongly Agree; 4 = Agree; 3 = Uncertain; 2 = Disagree;1 = Strongly Disagree). Items appearing on the TSI that address self-efficacy are as follows: "#19 I possess the ability to allow students to devise their own problems to investigate; #21 I will be able to play the primary role in guiding the identification of scientific questions; #26 I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence" (Smolleck & Yoder, 2006). TSI items relating to outcome expectancy are: "#25 I will expect students to ask scientific questions; #45 My students will engage in questions I have provided them; #55 My students will construct explanations from evidence using a framework I have provided" (p. 293-294).

According to the most recent research pertaining to the reliability and validity of the TSI, "item score to total test score correlation and item contribution to total test reliability were used to examine the construct validity of the items and the contributions each item made to the reliability of the instrument" (Smolleck & Yoder, 2008, p. 293). Furthermore, "item balance across the 24 variations of the essential features of classroom inquiry was also examined to determine the reliability of the instrument" (p. 293). Additionally, "coefficient alpha, a measure of internal consistency, was utilized to examine the reliability of the instrument (p. 293). These methods were utilized in combination “to identify the strongest combination of construct valid and reliable items that had balanced representation within the essential features of classroom inquiry and their variations” (p. 293). Data analysis revealed that “the overall reliability scores in relation to self-efficacy were: pre-test a of .9441 and a post-test a of .8911. The overall reliability scores in relation to outcome expectancy were: pre-test a of .9023 and posttest a of .9029” (p. 294). Furthermore, data associated with the essential features of classroom inquiry are as follows:

3.3 Coefficient Alpha Reliability Results for Self-Efficacy

Using data secured from the participants, a Coefficient Alpha was utilized to evaluate the TSI in terms of reliability. Results revealed the following for each of the subscales of the TSI: Learner Engages in Scientifically Oriented Questions (α = .80 for pre-test and .54 for post-test); Learner Gives Priority to Evidence in Responding to Questions (α = .75 for pre-test and .67 for the post-test); Learner Connects Explanations to Scientific Knowledge (α = .80 for pre-test and .71 for post-test); Learner Formulates Explanations from Evidence (α = .78 for pre-test and .62 for post-test); Learner Communicates and Justifies Explanations (α = .78 for pre-test and .76 for post-test). For further detailed information on the validity and reliability of the TSI Instrument, refer to Smolleck, Zembal-Saul, & Yoder (2006) and Smolleck & Yoder (2008).

3.4 Coefficient Alpha Reliability Results for Outcome Expectancy

A Coefficient Alpha was utilized to evaluate the reliability of the TSI and its subscales in relation to Outcome Expectancy. Results revealed the following for each of the subscales of the TSI: Learner Engages in Scientifically Oriented Questions (α = .69 for pre-test and .76 for post-test); Learner Gives Priority to Evidence in Responding to Questions (α = .68 for pre-test and .70 for post-test); Learner Formulates Explanations from Evidence (α = .74 for pre-test and .61 for post-test); Learner Connects Explanations to Scientific Knowledge (α = .62 for pre-test and .54 for post-test); Learner Communicates and Justifies Explanations (α = .65 for pre-test and .71 for post-test). For further detailed information on the validity and reliability of the TSI Instrument, refer to Smolleck, Zembal-Saul, & Yoder (2006) and Smolleck & Yoder (2008).

4. Analysis of Data

The Teaching Science as Inquiry (TSI) Instrument (Dira-Smolleck, 2004) was administered to the 38 pre-service elementary teachers using a pre-test/post-test design. This pre-test/post-test design was utilized to determine the extent to which the self-efficacy beliefs of the participants changed over time as a result of their educational experiences. Specifically the TSI was administered on four separate occasions: twice during the participants junior year and twice during the their senior year. During the junior year, participants were enrolled in a science methods course and administration took place at both the beginning (before instruction) of the semester and at the end of the semester. During the senior year, participants were completing their student teaching experiences and the TSI was administered again at the beginning of the semester and at the end of the semester.

In addition to quantitative data, qualitative data were also collected from the participants in an attempt to gather information concerning the critical events of each educational experience that influenced a change in participant self-efficacy in regard to the teaching of science as inquiry. Qualitative data sources included reflections completed by the participants at the end of the semester during both the junior and senior year. These reflective sources were completed on the same day as the TSI administration, However data analysis was completed separately from the quantitative sources. The methods of choice for analyzing this data were grounded theory and text analysis (Denzin & Lincoln, 2000).

During the junior year, while students were enrolled in a science methods course, reflections required participants to respond to the following prompts:

1) What components of the course were most useful for you in developing an understanding of teaching science as inquiry?

2) What additional experiences would have been useful for you in cultivating a better understanding of teaching science as inquiry?

In an attempt to understand the participants' experiences, the categories and concepts that emerged from participant responses to these prompts were identified. The researchers then linked these emerging ideas to substantive and formal theories (Denzin & Lincoln, 2000).

During the senior year, while students were completing their student teaching experiences, reflections required participants to respond to the following prompts:

1) During your student teaching experience, what was the most challenging aspect of teaching science?

2) During your student teaching experience, what was the most rewarding aspect of teaching science?

3) Were you able to implement science lessons/units that reflected inquiry-based methods?

4) If you answered "no" to the previous question, what factors interfered with your ability to teach science as inquiry?

5) If you answered "yes" what factors supported your efforts to teach science as inquiry?

6) If you were able to teach science as inquiry, what essential features of classroom inquiry were easiest to plan for?

7) If you were able to teach science as inquiry, what essential features of classroom inquiry were most difficult to plan for?

8) As a result of your student teaching experiences, what are your feelings/thoughts about teaching science as inquiry?

Again, in an attempt to understand the participants' experiences, the categories and concepts that emerged from participant responses to these prompts were identified and then linked to substantive and formal theories (Denzin & Lincoln, 2000).

4.1 Results: Science Methods Course

Examination of the quantitative data during the junior year while students were enrolled in a science methods course revealed that the mean and median values demonstrated a positive change for self-efficacy and outcome expectancy from pre-test (beginning of the semester) to post-test (end of semester). Specifically, data analysis from the pre-test revealed a mean self-efficacy score of 3.43 with a standard deviation of .49. The mean outcome expectancy score from the pre-test was 3.68 with a standard deviation of .38. Data analysis from the post-test indicated a mean self-efficacy score of 4.21 with a standard deviation of .33. The mean outcome expectancy score from the post-test was 3.97 with a standard deviation of .46 (theoretical score range for both the pretest and the post-test was 1 through 5). This data is significant in that it indicates that the participants' TSI scores increased from pre-test to post-test, thereby demonstrating an increase in preservice teachers self-efficacy over the course of the semester. The aforementioned results are summarized in Tables 1 and 2.

Qualitative data analysis revealed participants views concerning the critical incidents of each educational experience that influenced in a change in participant self-efficacy in regard to the teaching of science as inquiry, the following results were discovered:

Question #1: What components of the course were most useful for you in developing an understanding of teaching science as inquiry?

This particular question was administered to the participants at the end of the semester. The goal of asking this question was to further understand the ways in which self-efficacy may change over time and what factors may influence these changes. Overwhelmingly, the most notable component of the course mentioned by the participants was the "inclusion and implementation of investigations" (89%). Because the course is taught using inquiry as a means for teaching and learning, this response refers to the various opportunities the participants had to experience inquiry learning first hand. During each class session, students were engaged in scientific inquiry and were required to solve problems through investigation. Each of these experiences incorporated the essential features of classroom inquiry and required participants to utilize critical thinking. Topics for these investigations included: density, pollution, pendulums, matter, sound, electricity, magnets, simple machines, etc.

Other important components revealed in the responses included "deconstructing lessons" to identify the essential features (29%), "planning inquiry oriented lessons" (29%), "presenting student created inquiry lessons" to peers (29%), "utilizing the 5E model during planning" (26%), "utilizing the essential features of classroom inquiry for planning purposes" (17%), and "revamping a traditional lesson" into an inquiry lesson (14%). These particular features emerged as key elements within the course, therefore in an attempt to further improve the self-efficacy beliefs of pre-service teachers, these elements should continue to be a part of the curriculum.

Question #2: What additional experiences would have been useful for you in cultivating a better understanding of teaching science as inquiry?

Similar to question number one, this particular question was also administered to the participants at the end of the semester. The goal of asking this question was to ascertain from the participants, the additional experiences that would have been useful for developing a better understanding of teaching science as inquiry. The most common responses were the addition of a "field placement" component to the course (23%) and having the opportunity to "teach lessons to elementary aged children" (20%). These responses are notable in that they indicate that the participants desired to have opportunities to use inquiry based teaching methods with young children. This suggests that the participants felt comfortable enough with their own understandings of inquiry to offer inquiry-based learning opportunities to children. The notion of including a field placement component to the course is a valid idea and something that is currently being pursued. Adding this component to the course would be helpful in providing participants with the experience of teaching science as inquiry to elementary children. This application to the elementary classroom setting would further assist pre-service teachers in cultivating a more comprehensive understanding of teaching science as inquiry.

Other responses included "more practice developing lessons and units" (9%), and "more opportunities for class presentations" of lessons and units (9%). This response is encouraging and interesting because it suggests that the participants desired to have more assignments. This desire to have more assignments is usually not a typical request of college students, but indicates that the assignments are purposeful in leading to better understandings of inquiry-based teaching and learning.

4.2 Results: Student Teaching Experience

Examination of the quantitative data during the senior year while students were completing their student teaching expereince revealed that the mean and median values again demonstrated a positive change for self-efficacy and outcome expectancy from pre-test (beginning of the semester) to post-test (end of semester). Specifically, data analysis from the pre-test revealed a mean self-efficacy score of 4.04 with a standard deviation of .24. The mean outcome expectancy score from the pre-test was 3.84 with a standard deviation of .39. Data analysis from the post-test indicated a mean self-efficacy score of 4.25 with a standard deviation of .40. The mean outcome expectancy score from the post-test was 3.86 with a standard deviation of .54 (theoretical score range for both the pretest and the post-test was 1 through 5). This data is significant in that it indicates that the participants' TSI scores increased from pre-test to post-test, thereby demonstrating an increase in preservice teachers self-efficacy over the course of the semester. The aforementioned results are summarized in Tables 3 and 4.

Qualitative data analysis was collected at the end of the semseter. Data revealed participants views concerning the critical events of each educational experience that influenced in a change in participant self-efficacy in regard to the teaching of science as inquiry. Each question was administered at the end of the semester, and the following results were discovered.

Question #1: During your student teaching experience, what was the most challenging aspect of teaching science?

The most common responses were lack of "time" (35%) and "planning content that is developmentally appropriate" (15%). Other responses included "classroom management" (10%), "balancing inquiry with the academic standards" (10%), and lack of "resources" (10%). These responses are consistent with research that has reported potential explanations for the omission of inquiry-based science teaching practices (Enochs & Riggs, 1990; Hinrichsen, Jarrett, & Peixotto, 1999; Johnson, 2006). For example, time constraints are a common area of concern given the fact that the inquiry process does take time. However, if educators do not allow students the opportunity to think about their learning, then the sophistication of the learning will certainly suffer. All too often, "thinking is inhibited by a schedule that is structured around 45-minute periods" (1999. p. 12). This then leads to choices in "content that lends itself to easy management and immediate measurement" (1999, p. 12). This reality is exacerbated by the high stakes nature of standardized testing in our schools. As a result, "more time consuming concepts and skills are put off to the end of the school year, so that many topics can be covered to prepare students for upcoming state and district standardized tests" (1999, p. 12).

Question #2: During your student teaching experience, what was the most rewarding aspect of teaching science?

The most common responses were "student understanding" (25%) and "student enjoyment" (15%), and "student enthusiasm" (15%). Other responses included "student interest after the completion of the unit" (10%), and "student engagement" with content (10%). What is encouraging about these responses is that the participants exhibited a shift of concern. Specifically, their concern as evidenced by these responses was more focused on the students in the their classrooms, rather than on themselves as teachers. Seeing the benefits of student learning and engagement provided the catalyst for the participants to continue planning and implementing inquiry-based learning experiences, even though it may have taken a bit longer in comparison to more traditional forms of teaching.

Questions #3: Were you able to implement science lessons/units that reflected inquiry-based methods?

For this question, 75% of the participants responded “yes,” while 25% responded “no.” These results are both encouraging and disappointing. They are encouraging because the majority of student teachers did have the opportunity to teach inquiry-based methods, however there were still instances where these opportunities were not provided. One would hope that all student teachers would at least have the opportunity to attempt to implement lessons and/or units that reflect inquiry-based methods.

Question #4: If you answered “no” to the previous question, what factors interfered with your ability to teach science as inquiry?

For those students that did not have the opportunity to teach science as inquiry, the most common factors that interfered with their ability to do so were “time” (25%), “cooperating teacher’s teaching style” (15%), “meeting the requirements of the state standards” (15%), and having a “curriculum that is firmly established” (10%). Similar to question #1, these responses are consistent with research that has reported potential explanations for the omission of inquiry-based science teaching practices (Enochs & Riggs, 1990; Hinrichsen, Jarrett, & Peixotto, 1999; Johnson, 2006). It is important to note the significance of the cooperating teacher’s role on the ideals and behaviors of a student teacher. A considerable amount of research indicates the extreme value of the cooperating teachers during the student teaching experience (Booth, 1993; DelGesso & Smith, 1993; Guerrieri, 1976; Karmos and Jacko, 1977; Manning, 1977; McNally, Cope, Inglis, & Stonach, 1994; Stark, 1994). In fact, Guerrieri (1976) identifies the cooperating teacher as the “most significant person” having influence on the student teacher (p. 300).

Question #5: If you answered “yes” what factors supported your efforts to teach science as inquiry?

The factors that contributed most to the participants efforts were the “support of the cooperating teacher” (20%), having “resources available” (10%), being assigned “content” that the participants deemed more appropriate for inquiry-based teaching (10%), “seeing more student learning” as compared with traditional methods of instruction (10%), “student enjoyment” of content and learning (10%), more “student understanding” as compared with traditional methods of instruction (10%), and the “use of the 5E instructional model” during the planning of units/lessons (10%). As evidenced by the responses, participants again solidify the importance of the cooperating teacher. In addition, seeing the effects of inquiry-based learning opportunities reflected in student engagement and understanding was a significant factor. The 5E instructional model as a resource for planning units/lessons also provided support for the participants in that it gave them the structure for organizing developmentally appropriate experiences in a coherent, logical progression.

Question #6: If you were able to teach science as inquiry, what essential features of classroom inquiry were easiest to plan for?

The responses for this question indicated confusion on the part of the participants. Specifically, 50% of the participants confused the essential features of classroom inquiry with the 5E model. Participants indicated that the “engage” and explore’ portions of their lessons/units were the easiest to plan for (35%), followed by explain (10%). Only 5% of the participants identified an essential feature of classroom inquiry, specifically “learner engages in scientifically oriented questions” as easiest to plan (5%). Although the 5E instructional model and the five essential features of classroom inquiry are inherently different, it is understandable how students might confuse the two, especially considering the time between the science methods course (where they initially learned these concepts) and the student teaching experience. However, a more concerted effort must be taken to ensure that this confusion does not continue to exist with future preservice teachers.

Question 7: If you were able to teach science as inquiry, what essential features of classroom inquiry were most difficult to plan for?

Again, participant responses revealed confusion of the essential features of classroom inquiry with the 5E model instructional model (55%). As such, 20% of the participants identify explain (20%) and evaluate (20%) as most difficult to plan for. Unfortunately, none of the participants accurately referenced the essential features of classroom inquiry. These responses as well as responses from Question #6 indicate that more attention and focus needs to be placed on distinguishing between the essential features of classroom inquiry and the 5E instructional model. It would even be useful to have these two concepts be explored more fully in multiple courses rather than having them subsumed only within the science methods course.

Question #8: As a result of your student teaching experiences, what are your feelings/thoughts about teaching science as inquiry?

The most common feelings/thoughts about the teaching of science as inquiry were “love it/like it (30%), it is a “good idea” (20%), and it “isn’t easy” to teach science as inquiry (20%). Additional responses included that teaching science was "more enjoyable" for both the teacher and students (15%), provided more "meaningful student learning" (15%), and many of the participants mentioned that they will "incorporate inquiry teaching and learning into their future lessons/units" (15%). These responses are encouraging in that they represent positive orientations associated with inquiry-based teaching and learning. As a result, based on Bandura's (1977) social learning theory, we can expect that these particular student teachers will be likely to incorporate inquiry-based teaching and learning into their future teaching practices.

5. Discussion

The data and associated analyses demonstrate that carefully constructing science methods courses and student teaching experiences that allow pre-service teachers opportunities to experience the teaching and learning of science as inquiry is critical for improving self-efficacy. If inquiry-based teaching is to become a consistent feature within our elementary science classrooms, pre-service teachers must first have successful experiences learning science as inquiry (Palmer, 2006; Enochs & Riggs, 1988; Enochs & Riggs, 1990). They themselves must experience how learning science as inquiry takes place within an elementary school setting (Windschitl, 2002). Based on the idea of social learning theory (Bandura, 1977), pre-service teachers will be more likely to implement inquiry-based teaching methods in their future elementary classrooms if they have been provided with opportunities to experience success within a science methods course or student teaching experience. Thus, teacher preparation has become a logical target for change. Considering the encouraging notion of self-efficacy being malleable, science educators should deliberately plan for experiences that improve the self-efficacy beliefs of pre-service teachers. Experiences such as these can improve pre-service teachers' self-efficacy related to the teaching of science as inquiry and can assist them in developing more sophisticated understandings about teaching and learning science as inquiry. This in turn may promote the success of elementary students in the area of science.

The beliefs that teachers hold concerning the teaching of science as inquiry are at the core of educational change. As teacher educators, we have the potential to provide pre-service teachers with successful inquiry science experiences. Based on the idea of Bandura's social learning theory (1977), if science education reform is to be successful for our elementary children, pre-service teachers must feel confident in their abilities to teach science as inquiry.

This study supported the notion that self-efficacy can be enhanced as a result of experience, particularly positive experiences. Because of the relationship between beliefs, attitudes and behavior with regard to elementary science teaching, efficacy beliefs are potentially powerful variables that can influence the amount of time provided for science instruction, as well as the academic achievement of students in science at the elementary level. The results of this research provide valuable information pertaining to the education of future teachers as well as practicing teachers. Moreover, this project has the potential to lead science educators to a better understanding of how to best approach the issue of self-efficacy when planning and teaching science methods courses and supervising student teaching experiences with preservice elementary teachers. "Understanding teachers' beliefs, attitudes and priorities, as well as how they are subject to change in relation to a new intervention, is important to explaining students' and teachers' classroom experience" (Rimm-Kaufman & Sawyer, 2004, p. 322). Investigation and attention toward improving the self-efficacy beliefs of elementary teachers may contribute to the amelioration of the low priority that inquiry science teaching is currently given within our elementary schools.

6. Conclusions

Self-efficacy is a powerful paradigm that "operates on motivation" (Bandura, 1999, p. 214). Self-efficacy determines how much of a challenge one will undertake and how much effort is put into a project (Bandura, 1977; 1999). Self-efficacy influences "the choices individuals make and the courses of action they pursue" (Pajares, 1996). The higher one's efficacy is, the greater effort, persistence, and resilience they will display (Bandura, 1977; 1997). These three features are important characteristics for teachers and for the classroom environment. It can be thought that with a higher sense of self-efficacy a preservice teacher will be more willing to plan and implement lessons which offer experiences for the teaching and learning of science as inquiry.

However, an area warranting further consideration is the notion of varying types of teacher efficacy. Although, this study, as well as previous research associated with self-efficacy found a positive relationship between self-efficacy and beliefs, Wheatley (2000; 2002) considers certain types of positive teacher efficacy as problematic. In particular Wheatley's (2000; 2002) asserts that teacher doubts can have valuable bearing on continued professional development and educational reform. Although these ideas are contradictory to most of the research on teacher efficacy, they certainly provide an avenue for further exploration, which may lead to a deeper understanding of the efficacy beliefs of teachers. As a result we may be better able to encourage specific types of teacher efficacy that support teacher development and thereby restore the prominence of science in our elementary classrooms.

Self-efficacy can be a valuable tool for investigating the low priority that science is given in elementary classrooms. Science is taught about one fifth the amount of time as reading and language arts (Fulp, 2002). Science experiences in elementary schools need to increase and with a higher self-efficacy in the field, teachers will likely be more willing to increase the amount of time they devote to the teaching of science as inquiry. Only 74% of science teachers view problem solving/inquiry skills as heavily important in their classroom and would consider developing these skills (Weiss, 1994). Because about a quarter of the teachers do not view inquiry teaching as important, it is imperative to work toward adjusting these beliefs. The Pennsylvania State Board of Education has identified inquiry and design as one of eight key components of science instruction, which supports the notion of increasing the 74% statistic (Pennsylvania State Board of Education, 2002).

While interpreting the ways in which the self-efficacy beliefs of pre-service teachers in relation to the teaching of science as inquiry change at various stages in the pre-service teachers educational career, we believe that this research provided powerful reasons for continuing to foster improved levels of self-efficacy through course design. Additionally, in light of the findings from the reflections, we have identified experiences that were most useful for the participants in cultivating a better understanding and higher self-efficacy in relation to the teaching of science as inquiry. As such, these experiences can be perceived as recommendations for designing experiences that increase the self-efficacy beliefs of pre-service teachers. If pre-service teachers have high self-efficacy, this should give us hope that they will be more likely to plan inquiry based learning experiences during their student teaching experience as well as in their future elementary classrooms.

Additionally, it would be advantageous to follow participants into their future elementary classrooms to determine if connections exist between these findings and future teaching practices. For example, this research indicated the importance of cooperating teacher support in the participant's ability to teaching science as inquiry. As a result, it would be interesting to determine if lack of cooperating teacher support and lack of opportunities to teach science as inquiry leads to teaching practices that do not reflect inquiry based methods. Conversely, does the support of a cooperating teacher and having opportunities to teach science as inquiry lead to more reform oriented teaching, specifically the inclusion of inquiry-based teaching and learning in science. Investigating the future teaching practices of the participants might shed light on the long-term effects of the science methods course and the student teaching experience. This evaluation of pre-service teachers in various stages of their teaching career will begin to assist researchers and teacher educators in better understanding the connection between self-efficacy and the teaching of science as inquiry, as well as the ability to apply this knowledge to classroom practices. If teachers have high self-efficacy beliefs in the field of science education, then the outlook for the future of elementary school science is bright (Hetcher, 2010).

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Table 1. Pre-test results: science methods course

Sub-Scale	*n*	Items	Mean score	Standard deviation
Self Efficacy	38	34	3.43	.49
Outcome-Expectancy	38	35	3.68	.38

Table 2. Post-test results: science methods course

Sub-Scale	*n*	Items	Mean score	Standard deviation
Self Efficacy	38	34	4.21	.33
Outcome-Expectancy	38	35	3.97	.46

Table 3. Pre-test results: student teaching experience

Sub-Scale	*n*	Items	Mean score	Standard deviation
Self Efficacy	38	34	4.04	.24
Outcome-Expectancy	38	35	3.84	.39

Table 4. Post-test results: student teaching experience

Sub-Scale	*n*	Items	Mean score	Standard deviation
Self Efficacy	38	34	4.25	.40
Outcome-Expectancy	38	35	3.86	.54