Developing preservice teachers' self-efficacy through field-based science teaching practice with elementary students

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ABSTRACT

Thirty preservice teachers enrolled in a field-based science methods course were placed at a public elementary school for coursework and for teaching practice with elementary students. Candidates focused on building conceptual understanding of science content and pedagogical methods through innovative curriculum development and other course assignments during the first ten weeks. Teaching practice with fifth-grade students at the hosting elementary school occurred over a five-week period towards the end of the course. The researcher sought to determine if teacher candidates' confidence would rise in a teacher preparation environment that included exposure to authentic teaching practice. A pretest-posttest administration of the STEBI-B determined that general efficacy and personal science teaching efficacy (PSTE) increased significantly as hypothesized. Science teaching outcome expectancy (STOE) increased, but to a lesser degree.

Key words: Self-efficacy, field-based teacher preparation, preservice teachers, teaching practice

INTRODUCTION

A renewed interest in science education reform as conveyed in the Next Generation Science Standards (Achieve, 2013) calls for preparing students in STEM-related careers paths through innovative pedagogical strategies. According to the standards, a goal of science education should be to engage students in identifying real-life problems, dilemmas, or societal needs and planning a course of action or multiple ideas for solutions. With a vision towards producing a skilled, knowledgeable workforce, today's learners need creative opportunities to collaborate with peers to explore, pose questions, acquire knowledge, analyze and evaluate information, generate ideas, create and test models, and draw conclusions. Inasmuch as these skills are typically connected to science learning, the processes are applicable to many areas of students' lives. The problem is that elementary students may not be exposed to opportunities for such skill development in their classroom learning.

Imparting impactful learning experiences to students is a challenge for preservice teachers given that current science education reform requires staying abreast of constantly emerging scientific knowledge and technologies--and just as importantly—the research on how students learn. This researcher suggests from personal observations that the dilemma is further exacerbated in that elementary classrooms typically do not focus on practical learning that involves high-level scientific knowledge coupled with practices and skills enacted in collaborative contexts. Due to the Next Generation Science Standards' (Achieve, 2013) formidable demands for greater rigor in the sciences and on science education to prepare students for the 21st century workforce, elementary preservice teachers need to be trained in methods that go beyond the traditional lecture and testing protocol. Furthermore, unless elementary students experience early exposure to exploratory science connected to the stipulations of current science education reform, they will most likely not be motivated nor adequately prepared for science studies in middle- and secondary schooling.

A proposed plan to simultaneously enhance elementary students' science education experiences and develop preservice teachers' curriculum planning during teacher preparation is to provide both populations with several prospects for learning experiences that will first, motivate and provide enjoyment of science and second, provide exposure to science content focused on conceptual development. One goal is to build elementary students' foundation for investigative science in middle school leading to scientific and engineering practices as called for in the current wave of science education restructuring. Unless elementary students develop conceptual understanding of basic science content, then identifying problems and designing solutions as advocated in the Next Generation Science Standards will most likely not occur in future science studies.

Students should learn science content and engage in process skills in constructive and meaningful ways; this requires that prospective teachers be well trained in the methods of science. Furthermore, preservice teachers need authentic teaching practice in schools to apply reform-minded learning encountered in teacher preparation and to build confidence for science teaching. Preservice teachers can provide needed support to practicing teachers as conduits in preparing students for future science studies. The purpose of this paper is to address two persistent issues in teacher preparation and science education: (a) the need for field-based preservice teacher preparation coupled with authentic practice to build confidence for teaching, and (b) the need for elementary students to experience science through engagement in motivating, student-centered activities that focus on conceptual development of science content.

THEORETICAL FRAMEWORK

Overview of Self-Efficacy

Bandura (1986, 1977) introduced the construct of a "self system" to broaden the significance of social cognitive theory, which explains how a person cognitively processes and interprets environmental influences and how certain patterns of behavior are acquired and sustained. According to Bandura (1986), how humans function and perform is an interaction between personal, behavioral, and environmental influences. The degree of effort, perseverance, and flexibility is dependent on the individual's sense of self.

A strong sense of self-efficacy enriches human accomplishment and personal well-being (Bandura, 1997). Self-efficacy is what a person believes can be accomplished using his or her skills under certain circumstances. Self-efficacy beliefs influence the choices an individual makes and the courses of action that are pursued. Due to the effects on a person's life, self-efficacy beliefs are an important aspect of human motivation and behavior. Human motivation, personal accomplishment, and well-being drive self-efficacy, as exemplified when a person believes in his or her capacity to succeed in a given situation, pursue goals, and persevere in the face of challenge, adversity, or setback (Bandura, 1986, 1997).

Bandura (1977) defined "perceived self-efficacy" as one's beliefs about the capacity to produce designated levels of performance and influence outcomes and events affecting their lives. Bandura (1977) identified four sources that inform the development of self-efficacy beliefs: enactive mastery experiences (performance accomplishments), vicarious experiences, verbal persuasion, and physiological and affective states (emotional arousal).

Self-efficacy has been associated with constructs such as student achievement and motivation, teachers' willingness to adopt innovative teaching strategies, time spent on teaching certain subjects, cultural competence, alternative conceptions of science, and classroom management beliefs. Teachers' levels of efficacy have also been linked to content and methodological preparation (Czerniak, 1989, 1990), sense of responsibility for student achievement, and teacher retention rates (Darling-Hammond, Chung, and Frelow, 2002).

According to Gorski, Davis, and Reiter (2012), teachers and teacher educators are increasingly recognizing the significance of the connection between self-perception of teaching ability and competence to teach. Bandura (1997) suggests that self-efficacy may be most vulnerable to change during the early learning years. The importance of this assumption is that teachers' beliefs and self-efficacy about their ability to successfully carry out specific tasks and actions are perhaps most susceptible to influence during student teaching and the first year of inservice teaching.

Riggs and Enochs (1990) concluded that the manner in which preservice teachers view themselves and their roles in science teaching is partly derived from their self-efficacy and thus affects persistence, classroom academic focus, and other classroom behaviors. The researchers introduced the concept of science teaching efficacy beliefs, which refers specifically to perceptions about practicing and preservice teachers' confidence level in the ability to influence student learning in relation to science. According to Riggs and Enochs (1990), this construct is comprised of two specific, uncorrelated types of beliefs: Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). PSTE refers to belief in one's ability to effectively teach science, while STOE refers to the belief that if one teaches science effectively using appropriate methods, then students will learn.

Because teaching efficacy is thought to be subject matter and context specific, (Tschannen-Moran et al., 1998), the Science Teaching Efficacy Beliefs Instrument (STEBI) was developed by Riggs & Enochs (1990) to measure efficacy for science teaching in practicing teachers. Enochs and Riggs (1990) subsequently developed a version of the STEBI for preservice teachers known as STEBI-B. Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) are subscales in both surveys. The STEBI-B has been used in various studies examining the effects on preservice teachers' efficacy for teaching as will be elucidated in the review of the literature that follows.

Teacher Preparation and Self-Efficacy

The literature reports studies from various perspectives related to preservice teachers' self-efficacy in science teaching. A growing body of scholarship suggests that preservice teachers' efficacy may be significantly influenced by their teacher preparation program and field experiences. For example, the Professional Development Schools (PDS) preparation model (Holmes Group, 1990) is a partnership between teacher education programs and P-12 schools that combines the functions and purposes of these entities in regards to preservice teacher, mentor teacher, and teacher educator professional development (Capraro, Capraro, & Helfeldt, 2010). Furthermore, professional learning communities, inquiry-based teaching and learning, and student outcomes are often emphasized. Research on PDS indicates that preservice teachers are better equipped to plan lessons and cope with the realities of teaching than prospective teachers not trained in PDS (Ridley, Hurwitz, Hackett, & Miller, 2005). Although PDS have been linked to general effectiveness in preservice teacher preparation, the literature mostly reports on the unique attributes of the model and less on the model's connection to student learning outcomes.

Wingfield, Nath, Freeman, and Cohen (2000) examined the effects on self-efficacy beliefs by placing the entire population of preservice teachers from a university teacher preparation program in Professional Development Schools (PDS) for one year. Pre-service teachers were exposed to effective modeling by mentor teachers, engaged in authentic teaching experiences, and received ongoing support and encouragement during the year. Pretest-posttest results of the Science Teaching Efficacy Beliefs Instrument (STEBI-B) determined that self-efficacy increased from the beginning to the end of the year. The authors maintain that self-efficacy in prospective teachers may increase if engaged in context-specific learning experiences coupled with ongoing support from teacher preparation professors and mentor teachers in field experiences.

A study by Woolfolk Hoy and Burke Spero (2005) using multiple quantitative assessments of self-efficacy concluded that preservice teachers' sense of efficacy increased from the beginning to the end of a teacher preparation program, but decreased from the end of their preparation program to the end of the first year of inservice teaching. The authors conjecture that the decrease resulted from the withdrawal of support received in teacher preparation as compared to the first year of teaching. Similarly, Barnes (2000) found that prospective teachers' sense of efficacy increased during their teacher preparation program, but declined as they advanced through their program of studies to become practicing teachers. The author attributes the decline to awareness of the intricate nature of teaching by the end of teacher preparation. Ashton and Webb (1986) contend that preservice teacher self-efficacy varies during the course of teacher education due to fluctuations in both successful and unsuccessful learning experiences and influences. The authors suggest that the organizational structure of schools in which preservice teachers are placed for professional development may be a significant contributing factor to this variation.

However, not all studies report an increase in self-efficacy due to the influence of teacher preparation. For example, Plourde (2002) ascertained that student teaching resulted in statistically significant negative changes in preservice teachers' outcome beliefs, perhaps due to influences causing deterioration of confidence during clinical practice. Gencer and Çakiroğlu (2007) found that taking additional teacher education courses did not contribute significantly to increasing preservice teachers' self-efficacy beliefs. Using a pretest-postest protocol of the Science Teaching Efficacy Beliefs Instrument-B (Enochs & Riggs, 1990) on 185 elementary preservice teachers, a study on self-efficacy by Yilmaz and Çavaş (2008) determined that a majority of the preservice teachers' science teaching self-efficacy scores did not increase with teaching practice experience.

Field Experiences and Self-Efficacy

The research based on field experience is not extensive according to Capraro, Capraro, and Helfeldt (2010). In regards to field experiences and self-efficacy, Davis, Petish, and Smithy (2006) propose that weaving site-based experiences with science methods courses contributes to both preservice teachers' understanding of science teaching and increased teaching efficacy. Whereas extensive and well-crafted field experiences develop positive attitudes toward teaching, self-confidence, and enhanced knowledge of the teaching profession (Thomson, Beacham, & Misulis, 1992), negative field experiences may promote undesirable attitudes about teaching and low self-efficacy in preservice teachers (Fallin & Royse, 2000). Aydin and Woolfolk Hoy (2005) identified significant predictors of preservice teachers' sense of efficacy: (a) the relationship between preservice teacher and mentor supervisor; (b) the quality of support from the cooperating teacher, the school community, and the field placement supervisor; and (c) the number of field experiences.

A study by Li and Zhang (2000) on the effects of early practicum experiences on prospective teachers' self-efficacy revealed correlations between field experience perceptions and self-efficacy for teaching. First, preservice teachers' posttest general teaching efficacy scores were lower than their pretest general teaching efficacy scores, while their posttest personal teaching efficacy score were higher than corresponding pretest scores. Second, preservice teachers with high ratings of their early field experience also had higher posttest personal teaching efficacy scores. Conversely, preservice teachers with low early field experience ratings had lower posttest personal teaching efficacy scores. Third, preservice teachers who rated their cooperating teachers high on efficacy beliefs had higher general teaching efficacy scores, while the converse was true.

Similar to the results obtained by Li and Zhang (2000), Cannon and Scharmann (1996) determined through the Science Teaching Efficacy Beliefs Instrument (STEBI-B) that elementary preservice teachers who engaged in early field experiences during their science methods course had higher self-efficacy scores than elementary preservice teachers that did not have early field experiences in elementary classrooms. In their methods course, these preservice teachers in cooperative learning groups planned a science lesson that was taught in a cooperative teaching field experience.

McDonnough and Matkins (2010) examined the effects of embedded, concurrent field experiences in science methods courses when compared to science methods courses without an embedded field experience. Over the four-year study, results gleaned from the Science Teaching Efficacy Beliefs Instrument (STEBI-B) and from structured interviews revealed that preservice teachers' self-efficacy consistently increased in comparison to preservice teachers whose field practicum experience was not connected to their science methods course.

In contrast, Capraro, Capraro, and Helfeldt (2010) maintain that field experiences do not necessarily connect theory to practice since field experiences may vary in their scope and focus including observations in P-12 classrooms, teaching small and whole groups of students, and tutoring individual and groups of students in classrooms or in before- or after-school programs. A study by Ohana (2004) focusing on a comparison of two science methods courses found that general field experiences did not significantly contribute to preservice teachers' understanding of science education. Wagler (2011) similarly found no positive change in preservice teachers' self-efficacy as a result of vicarious experiences provided by cooperating teachers during field-based science education experiences. Gencer and Çakiroğlu (2007) ascertained that field-based practice teaching was not a significant factor in preservice teachers' self-efficacy beliefs.

Teacher Preparation Coursework and Self-Efficacy

Self-efficacy has also been examined through the lens of specific teacher preparation coursework and training. Mosley, Reinke, and Bookout (2002) determined that preservice teachers' general self-efficacy remained unchanged throughout training and teaching experiences in an outdoor environmental education program but decreased significantly several weeks after teaching. However, outcome expectancy reflected no significant change due to participation. Avery and Meyer (2012) reported that prospective teachers enrolled in an environmental biology for preservice teachers course increased their self-efficacy for teaching and learning as well as their conceptual understanding of inquiry and scientific research. A qualitative study by Carrier (2009) concluded that preservice teachers' confidence level for science teaching increased due to participation in a science methods course focusing on teaching outdoor science lessons. Field notes, student reflections, and interviews revealed (a) effective modeling of science teaching by mentors, (b) direct work with students in outdoor science activities, and (c) witnessing student excitement as major contributors to preservice teachers' increase in confidence.

Developing cultural competence in preservice teachers supports their capacity to provide equitable access to learning for the diversity of students they will teach. The ability to provide purposeful science learning to racial/ethnic students, low-income students, and students with special needs has been associated with teacher self-efficacy. For example, Cone (2009) holds that preservice teachers often enter student teaching with low science teaching efficacy and a weak understanding of diversity that impairs the capacity to impart high-level science instruction. Regarding beliefs about equitable science teaching and learning, the researcher concluded that the inclusion of community-based service learning in a science methods course increased preservice teachers' science teaching outcome expectancy (STOE), but not personal science teaching efficacy (PSTE).

A study by Leonard, Barnes-Johnson, Dantley, and Kimber (2011) of preservice teachers' efficacy beliefs connected to inquiry-based science practices in urban classrooms found that personal science teaching efficacy (PSTE) increased, but science teaching outcome expectancy (STOE) did not increase. The authors propose that mastery experiences (Bandura, 1977) should be developed through field experiences in community-based settings that provide preservice teachers with opportunities to "observe, reflect, create, and carry out inventive approaches to teaching and learning in authentic, diverse settings" (p. 148). Bianchini and Cavaros (2007) argue that cooperating teachers with poor perceptions of urban children may negatively influence preservice teachers self-efficacy for teaching.

In a study of the impact of tutoring culturally diverse learners in an urban field experience, Lastrapes and Negishi (2011) ascertained that preservice teachers' teaching efficacy increased due to their ability to make connections between cultural competence and instructional practices. Data gathered from a self-assessment inventory on cultural sensitivity, an instrument on culturally sensitive teaching efficacy, and reflective journal blogs provided evidence that preservice teachers experienced an increase in their levels of self-efficacy and cultural sensitivity due to tutoring experiences of culturally diverse students.

In a study on the impact of vicarious experiences and field experience classroom characteristics on 46 elementary preservice teachers' science teaching efficacy, Wagler (2011) determined that student ethnicity and socioeconomic status negatively impacted teaching efficacy levels. A surprising finding in Wagler's study is that observing successful performances (Bandura, 1977) by practicing teachers did not positively impact preservice teachers' science teaching efficacy during field experiences as would be expected. The author proposes that structured, coordinated efforts between teacher education faculty, cooperating teachers, and field placement schools be in place to provide effective support during field experiences. Important to note in a study by Darling-Hammond, Chung, and Frelow (2002) is that survey data from 3,000 teacher education graduates indicated that they rated their preparation as less than adequate for teaching English learners and special education students, although these graduates rated their preparation higher than those who entered the teaching profession through alternative programs.

Research Questions and Hypotheses

The purpose of this study was to examine the impact on elementary preservice teachers' self-efficacy of a field-based science methods course with embedded teaching practice. Three research questions defined the study:

1. Does a field-based science methods course with embedded teaching practice impact elementary preservice teachers' general science teaching efficacy?
2. Does a field-based science methods course with embedded teaching practice impact elementary preservice teachers' personal science teaching efficacy?
3. Does a field-based science methods course with embedded teaching practice impact preservice teachers' science teaching outcome expectancy?

Based on the notion that self-efficacy is thought to be subject matter and context specific (Tschannen-Moran et al., 1998), the researcher hypothesized that teacher candidates' general and personal efficacy for science teaching would rise due to a science methods course with embedded, interactive teaching sessions with elementary students. The researcher did not hypothesize the direction of science teaching outcome expectancy; however, previous research studies cited in the theoretical framework of this paper indicate that science teaching outcome expectancy may not increase in spite of an increase in general and/or personal science teaching efficacy.

METHOD

The study was a quantitative investigation that assessed the science teaching efficacy of prospective teachers who engaged in authentic teaching sessions with elementary students over a five-week period in a field-based science methods course.

Participants

The participants in this study were 30 undergraduate teacher education candidates from a mid-sized, four-year university in Southern California. All participants were enrolled in a multiple subject teacher preparation program that qualified them for a kindergarten through eighth-grade preliminary credential.

Program Design

The participants in this study were identified as upper division undergraduate teacher candidates enrolled in a blended teacher education program. The program consists of concurrent training in subject matter content through a Liberal Studies Program and in subject matter content with pedagogical methods through the School of Education. In a program that leads to a simultaneous baccalaureate degree in Liberal Studies and a preliminary multiple subject credential, these teacher candidates study subject matter during the same semester as they study methods of how to teach. For example, in the third semester of the blended program, a science content course is taken concurrently with a science methods course. This training experience spans a period of four themed academic semesters in cohort groups followed by a fifth semester of clinical practice.

Procedures

At the beginning of the spring 2013 semester, 30 undergraduate teacher candidates were placed at a public K-5 elementary school site for engagement in science methods coursework and for teaching opportunities with diverse elementary students. The justification was that candidates traditionally take all credential coursework on-campus, an arrangement that does not provide occasion to build confidence to confront the realities and challenges of teaching students. These prospective teachers do not have access to elementary classrooms, and there are no opportunities to work directly with students in the context of a school environment. Hence, the researcher arranged for the candidates to be placed onsite at the school for the extent of the 16-week science methods course.

The researcher taught the science methods course consisting of topics in physical-, life-, and earth science. The first ten weeks included an immersion of the candidates in science content knowledge coupled with learning pedagogical methods. Candidates developed content knowledge through (a) assigned readings with a "jigsaw" peer teaching component at the beginning of each class, (b) creating concept maps related to readings, (c) teacher-led discrepant events lessons, (d) candidate-generated discrepant events lessons, and (e) science resources available on the course Web site.

A signature course assignment was the creation of a hands-on, discrepant event (DE) science lesson that was collaboratively created by the teacher candidates. At the beginning of the course, the candidates were divided into ten groups of three; each group collaboratively decided on a fifth-grade standard topic on which to develop a DE lesson. The researcher provided indepth guidelines for the assignment and an organizing lesson template for the groups to complete and upload to the course Web site. Hence, candidates had access to all Discrepant Events lessons for future implementation with elementary students. Candidates were required to provide science content background information attached to their template beyond what was needed to teach their lesson. Therefore, the candidates developed additional science content knowledge on all DE lesson topics due to this requirement.

The researcher modeled some discrepant events during four class sessions to provide motivation (social persuasion), enjoyment, and to draw the candidates into science learning. As well, the modeling (vicarious experiences) provided candidates with a rationale for implementing such activities with students. Stimulating student thought and analysis through inquiry-based science activities whose outcomes run contrary to what students would have predicted provided a vehicle to form exploratory habits of mind in the candidates. Through purposefully structured questioning techniques and relevant science process skills, discrepant events provoke problem-solving and critical thinking.

An assignment stipulation was for each candidate to practice and video record the group lesson with non-school site students of his/her choice. The recording served to provide feedback to the candidate to refine content and pedagogical strategies if needed. Candidates consulted with their respective group, and lesson adjustments were made accordingly. During weeks six through nine of the course, groups jointly presented their lesson to peers during class time. Candidates observed each group in the act of presenting and teaching (vicarious experiences). For each DE lesson, the candidates recorded notes and drawings in a science notebook, and posed questions to presenting groups. This experience allowed opportunities for objective peer feedback to make any additional adjustments to the lessons. Furthermore, all candidates were exposed to the science lessons' topics in preparation for the teaching sessions with the hosting school's fifth-grade students in weeks ten through fourteen. As the Discrepant Events lessons were presented, the candidates were charged with carefully examining the lessons in preparation for the teaching sessions. The researcher created a five-week schedule indicating which two DEs would be taught per week, and prepared all materials needed each week for the 30 teaching groups of candidates and their assigned students.

Prior to the course, the researcher chose to work with the school's fifth-grade population (n=175) for the teaching sessions, a decision based on supporting their preparation for science standardized testing in the same spring semester. The researcher and the school principal assigned five to six fifth-grade students to each teacher candidate so that each individually taught the same students over the five weeks of the once-per-week teaching sessions.

Seven classrooms were designated as sites for the teaching episodes, with four to five candidates in each classroom with their assigned group of students. Preparation for each session consisted of the candidates taking presorted lesson materials to their designated students and classroom. Each candidate taught two lessons in each hour-long session, and specific "driving questions" focused students in each lesson. By the fourteenth week of the course, the teacher candidates had taught all ten DEs to their assigned fifth-graders.

The researcher observed and monitored teacher candidates in all classrooms each week and recorded anecdotal notes. At the conclusion of each session, the candidates returned to the cohort classroom and a debriefing discussion with the researcher ensued wherein candidates shared what went well and what challenges were encountered. In each of the five teaching session weeks, candidates were charged with uploading a specifically structured written reflection of their teaching experiences.

Instrument

The present study used the Science Teaching Efficacy Belief Instrument-Preservice (STEBI-B). Used in numerous studies (e.g. Jarrett, 1999; Tosun, 2000; Wingfield, Freeman, and Ramsey, 2000)), STEBI-B is an established instrument developed by Enochs and Riggs (1990) as a result of Bandura's self-efficacy theory (1977). STEBI-B measures science teaching self-efficacy and outcome expectancy in K-12 preservice teachers using two subscales that are considered accurate predictors of science teaching behavior: Personal Science Teaching Efficacy Belief (PSTE) and Science Teaching Outcome Expectancy (STOE). PSTE reflects the belief that an action can be successfully carried out, while STOE maintains that people will be motivated to perform a certain action if it is believed to have a favorable result.

The STEBI-B consists of 23 items in a five-point Likert-type scale ranging from strongly agree to strongly disagree. Twenty-three items measure PSTE and 10 items measure STOE. Enochs and Riggs (1990) established the validity and reliability of the STEBI-B, and after thorough analyses, the researchers concluded that the instrument could be considered reliable and reasonably valid with a stable and unified factor structure. Bleicher (2004) confirmed the basic integrity of the STEBI-B. However, a study of the instrument by Bleicher determined that two items on the STOE scale demonstrate weak association with the other STOE items based on wording. For purposes of the study discussed in this paper, this researcher used the two items as suggested by Bleicher (2004): eliminating the word "some" in items 10 and 13 to avoid confusion by responding participants. The omission does not change the negative direction of the items, however.

The items of the Science Teaching Efficacy Beliefs Instrument for preservice teachers (STEBI-B) were prepared for hard copy administration to the study participants. A scaled response format was used with the following response categories: Strongly Agree (SA), Agree (A), Uncertain (U), Disagree (D), and Strongly Disagree (SD). For quantitative evaluation purposes, each response category was given a numeric value from 1 to 5, with Strongly Agree (SA) having a numeric value of 5 and Strongly Disagree (SD) having a numeric value of 1. However, there were ten negatively worded STEBI-B items that were reversed scored to produce consistent values between positively and negatively worded items. Reversing these items produce high scores for those high and low scores for those low in efficacy and outcome expectancy beliefs (Enochs, Smith, & Huinker, 2000).

Data Collection

Teacher candidates completed a pretest STEBI-B (Enochs & Riggs, 1990) at the beginning of their science methods course and a posttest STEBI-B at the end of their science methods course after completion of a series of Discrepant Events teaching sessions. Candidates' demographic information and previous classroom experience information was gathered at the beginning of the course and is presented in Table 1 (Appendix A)

RESULTS

To answer the three research questions, descriptive statistics were used to analyze the teacher candidates' pretest-posttest STEBI-B scores in regards to general efficacy for science teaching, personal science teaching efficacy (PSTE), and science teaching outcome expectancy (STOE). The researcher hypothesized that teacher candidates' general efficacy and personal science teaching efficacy (PSTE) mean scores would increase from the beginning to the end of a field-based science methods course with embedded teaching practice. Therefore, one-tailed dependent samples t-tests at the 0.05 level of significance were conducted on both general efficacy and PSTE pretest-posttest scores. Science teaching outcome expectancy (STOE) mean scores were not hypothesized to either increase or decrease. Therefore, a two-tailed dependent samples t-test at the 0.05 level of significance was conducted on STOE pretest-posttest scores.

Statistical Analysis

Research Question 1 Analysis

A one-tailed dependent samples t-test on STEBI-B general efficacy scores was conducted to determine if there was a significant difference between teacher candidates' mean scores before and after participation in a field-based science methods course with embedded teaching practice. The means of pre- and posttest STEBI-B scores were 85 and 96.733 respectively. The results indicate a significant increase in teacher candidates' general efficacy mean scores, $t(29) = 5.710$, $p < .05$. The p-value suggests a significant difference between the mean scores of candidates' general science teaching efficacy beliefs before and after participation in a site-based science methods course. Table 2 (Appendix B) presents the means, standard deviations, p-value, and the calculated t-statistic.

Research Question 2 Analysis

A one-tailed dependent samples t-test on STEBI-B personal science teaching efficacy (PSTE subscale) scores was conducted to determine if there was a significant difference between teacher candidates' mean scores before and after participation in a field-based science methods course with embedded teaching practice. The means of pre- and posttest scores were 48.133 and 57.067 respectively. The results indicate a significant increase in teacher candidates' PSTE mean scores, $t(29) = 6.332$, $p < .05$. The p-value suggests a significant difference between candidates' PSTE mean scores before and after participation is a site-based science methods course. Table 3 (Appendix B) presents the means, standard deviations, p-value, and the calculated t-statistic.

Research Question 3 Analysis

A two-tailed dependent samples t-test on STEBI-B science teaching outcome expectancy (STOE subscale) scores was conducted to determine if there was a difference between teacher candidates' means scores before and after participation in a science methods course with embedded teaching practice. The means of pre- and posttest scores were 36.867 and 39.667 respectively. The results indicate a slight increase in candidates' STOE mean scores, $t(29) = 2.174$, $p < .05$. The p-value also reflects an increase in STOE mean scores. However, the increase was not as significant as the increase in general science teaching efficacy mean scores and PSTE mean scores. Table 4 (Appendix B) presents the means, standard deviations, p-value, and the calculated t-statistic.

DISCUSSION

Mastery experiences and personal accomplishments have been shown to influence and drive self-efficacy (Bandura, 1986, 1997). According to Bandura, mastery experiences are the most powerful source of efficacy information, and the perception of a successful performance increases efficacy beliefs and expectations of proficiency in future performance. Leonard et al. (2011) assert that mastery experiences should be acquired and developed through field experiences. Tschannen-Moran et al. (1998) contend that self-efficacy is specific to a particular task and is a judgment about task capability. Yilmaz and Çavaş (2008) suggest that the most important influence on teaching efficacy beliefs is the teaching practice experience. Riggs and Enochs (1990) point out that how preservice teachers view themselves and their roles in science teaching affects their persistence and classroom performance. Bandura (1997) conjectures that self-efficacy may be most vulnerable to change during the early learning years. These assumptions guided the researchers' study that examined the effects of field-based teaching practice on preservice teachers' efficacy for science teaching.

Methods courses have the potential to influence the practice of beginning teachers (Gess-Newsome, 1999) and provide strong contexts for preservice teachers' professional development if connected to elementary school practices (Castle, Fox, & Souder, 2006; Darling-Hammond, 2005). Wingfield, Nath, et al. (2000) acknowledge that field-based teacher preparation exerts lasting influence on science teaching efficacy beliefs that may extend throughout the first year of teaching. However, elementary preservice teachers are often placed in on-campus preparation programs where connections to classroom settings and authentic teaching opportunities during methods courses are not provided. Building confidence for science teaching calls for opportunities to design, plan, and implement activities in order to apply coursework learning and to gauge teaching effectiveness.

Given that self-efficacy is thought to be context and subject matter specific (Tschannen-Moran et al., 1998), this researcher sought to determine if teacher candidates' confidence would rise in a teacher preparation environment that included exposure to authentic teaching practice with elementary students. The researcher's science methods course with embedded field-based teaching sessions as a signature assignment provided candidates with opportunities to develop and apply pedagogical content knowledge gained in the course. Candidates in the present study were placed onsite at a local elementary school for both science education coursework and professional development. The rationale was that candidates would benefit from experiencing school culture while concurrently developing science curriculum and pedagogical methods in preparation for engagement with fifth-grade students at the hosting school. These context-specific teaching and learning experiences were hypothesized to increase the candidates' confidence for science teaching.

The results of the present study concur with the findings of Davis, Petish, and Smithy (2006) and Wingfield, Nath, et al. (2000) that site-based teacher training may result in significant gains in self-efficacy. In regards to general teaching efficacy, the data gleaned from this study indicates a significant increase in teacher candidates' general efficacy from the beginning to the end of the researcher's science methods course. That is, course requirements inclusive of planning and implementing science teaching practice with elementary students most likely positively impacted the candidates' overall confidence. However, other embedded factors in the course may have contributed to increasing candidates' overall teaching confidence. For example, general efficacy may have been influenced by candidates' collaborative work with peers in planning and teaching discrepant events (DE) lessons during the first ten weeks of the course before actual teaching sessions with elementary students. If candidates had lower self-efficacy beliefs at the beginning of the course, working with others to create stimulating lessons while simultaneously learning science content and innovative ways to teach appeared to have had a positive influence on efficacy.

Social (verbal) persuasion from peers may have also contributed to general efficacy as candidates were jointly planning and teaching lessons during coursework. Social persuasion may further have increased candidates' general efficacy when verbal feedback was provided after discrepant events lesson presentations to peers. Social persuasion demonstrated through the level of the fifth-grade students' enthusiasm, participation, and feedback during teaching sessions is also conjectured to have increased general self-efficacy. Furthermore, the researcher modeled four science DE lessons (vicarious experiences) at the beginning of the course, which may have contributed to positively influencing candidates' general efficacy beliefs. As Bandura (1977) points out, observation of an individual successfully modeling a given event typically raises the observer's efficacy beliefs. Unlike Wagler's (2011) finding, the current study confirms that enactive mastery experiences changed teacher candidates' science teaching efficacy beliefs.

In this study, teacher candidates' personal science teaching efficacy (PSTE) increased significantly from the beginning to the end of the science methods course. Although candidates worked collaboratively on planning, designing, and teaching lessons to peers, there were individual aspects of the course that are assumed to have contributed to personal efficacy beliefs. For example, content knowledge was developed through different learning experiences. Peer teaching of assigned readings in jigsaw activities, weekly concept maps based on assigned readings, science notebooks with recordings and drawings of teacher- and peer-led lessons, and additional science background information required for each discrepant event lesson were vehicles through which candidates' increased science content knowledge on an individual basis.

Personal science teaching efficacy was hypothesized to increase due mainly to mastery experiences and successful performance during individually taught discrepant events (DE) teaching sessions with assigned fifth-grade students. Candidates taught through questioning strategies that they created for all discrepant events lessons. High-level questions placed before, during, and at closure in the lessons were an essential component that prompted critical thinking and interactive scientific discussion between the candidates and their students. As well, social persuasion from the fifth-graders during the DE lessons was another factor that likely contributed to the rise in candidates' PSTE. Candidates often commented on students' high excitement about the science activities as enjoyable, "cool", and "awesome". Hence, social persuasion in the form of excitement and compliments raised teacher candidates' emotional arousal, which in turn increased feelings of personal competence and mastery (Bandura, 1986, 1997).

Weekly reflections required after each teaching session with their assigned fifth-grade students generally indicated increasing personal self-efficacy from the first to the fifth week of the teaching experience. Reflecting on teaching and adjusting accordingly for subsequent sessions required the candidates to improve pedagogical methods in response to their students' feedback (social persuasion) and academic performance.

Outcome expectancy is related to one's belief in how well students can actually be taught. Gibson and Dembo (1984) suggest that teachers who believe that effective teaching can positively impact learning and who also have confidence in their own teaching abilities should persist longer and provide deeper classroom academic focus. In contrast to studies by Wingfield and Nath (2000) and Leonard et al. (2011) in which teaching outcome expectancy did not increase in spite of field-based teacher preparation, the results of the present study reflect otherwise. Science teaching outcome efficacy (STOE) improved but not to the level that this researcher hoped for when compared to general and personal science teaching efficacy (PSTE). The results of this study mirror some previous studies in that personal science teaching efficacy increases while science teaching outcome expectancy either does not increase or increases slightly (eg., Leonard et al., 2011; Wingfield & Nath, 2000). A conjecture offered by Tosun (2000) suggests that the lack of change in outcome expectancy may be attributed to a lack of performance accomplishment in prior science coursework.

The present study indicates that science teaching outcome expectancy (STOE) increased by the end of the methods course after teaching practice had occurred. The contribution to teaching outcome expectancy of working directly with elementary students over a five-week period cannot be overlooked. Candidates designed and created student-centered, inquiry-based curriculum and practiced teaching the lessons with other elementary students and peers. Hence, the candidates gained more confidence in regards to student learning outcomes than if they had not practiced prior to the teaching sessions. As with the candidates' increase in general and personal teaching efficacy, STOE increased most likely due to (a) mastery experiences through practice teaching with students, peers, and fifth-graders, (b) vicarious experiences through the researcher's modeling of discrepant event lessons, and (c) social persuasion from peers and students.

Although science teaching outcome expectancy increased significantly in this study, prior research has shown that outcome expectancy may be resistant to change as a result of instruction. Williams (2010) holds that outcome expectancy is an important predictor of behavioral change. Maddux, Scherer, and Rogers (1983) ascertained that outcome expectancy (the results of an action) can influence intention to perform behavior (self-efficacy) but the converse was not found. Implications of the findings of Maddux et al. (1983) for this study are that candidates' expecting favorable teaching outcomes may have contributed to the increase in both general and personal teaching efficacy.

CONCLUSION

This study lends support to the notion of providing elementary preservice teachers with access to classroom settings for practice teaching in science to diverse learners. As Dodds (1989) points out, field experiences should provide a bridge between the theoretical components of formal teacher preparation and the practical realities of teaching.

There is a need to purposefully link research to practice by providing systematically structured field experiences that involve authentic teaching practice in classrooms. Certain conditions need to be in place to increase the probability that field experiences will produce the desired effects of increasing preservice teachers' personal confidence to teach science effectively. The preservice teachers in this study commenced their science methods course with a variability of teaching self-efficacy, but ended the course with a positive view of themselves in general and specifically about their ability to be transformational science teachers who could effectively deliver science content in an effective manner and influence student achievement.

As this study has shown, preservice teachers' personal science teaching efficacy (PSTE) may increase significantly in comparison to science teaching outcome expectancy (STOE), which in the case of the present study, increased significantly. Or, as other studies have demonstrated, STOE may decrease or remain unchanged. It is interesting to note that while preservice teachers may believe they can effectively teach science, their belief in the ability to influence student learning is less certain. Future studies should focus more stridently on examining why STOE does not increase in spite of increases in PSTE and general efficacy. In order to ensure that preservice teachers are provided with appropriate mastery and vicarious experiences in science education, teacher educators should advocate for integrated methods in field-based science courses that facilitate stimulating, appealing science learning while simultaneously building teaching confidence to positively influence student learning outcomes.

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APPENDIX A

Table 1

Teacher Candidate Demographic Information (n = 30)

Gender				
Male	Female			
1	29			
Age				
Under 25 years	25 – 29 years	30 – 39 years		
23	5	2		
Previous Teaching or Classroom Experience				
Yes	No			
29	1			
Years of Previous Teaching or Classroom Experience (including substitute, aid, tutor)				
0-1 years	2-3 years	4-5 years	6-7 years	>7 years
13	9	5	1	2

APPENDIX B

Table 2
t-Test Paired Two Sample for Means (STEBI-B General Science Teaching Efficacy)

	Pretest Scores	Posttest Scores
Mean	85.000	96.733
Variance	80.828	48.064
Observations	30	30
S.D.	8.990	6.933
t	-5.710	
p-value	1.771E-06	
t critical	1.699	

Table 3
t-Test Paired Two Sample for Means (STEBI-B Personal Science Teaching Efficacy)

	Pretest PSTE Scores	Posttest PSTE Scores
Mean	48.133	57.067
Variance	46.395	16.478
Observations	30	30
S.D.	6.811	4.059
t	-6.332	
p-value	3.220E-07	
t critical	1.699	

Table 4
t-Test Paired Two Sample for Means (STEBI-B Science Teaching Outcome Expectancy)

	Pretest STOE Scores	Posttest STOE Scores
Mean	36.867	39.667
Variance	32.464	20.575
Observations	30	30
S.D.	5.698	4.536
t	-2.174	
p-value	0.038	
t-critical	2.045	