Preservice teachers as investigative science mentors: Advancing self-efficacy through school-based professional development

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ABSTRACT

Pedagogical competence and teaching efficacy significantly influence the quality of classroom science learning. Without applying pedagogical learning in realistic classroom environments, there is slight possibility that prospective teachers will increase their teaching confidence or develop understanding of how learners acquire and construct knowledge. The current shift in science education reform calls for students to experience how science is authentically enacted. Twenty-two undergraduate teacher candidates were placed at an elementary school for teacher preparation studies and for opportunities to apply their coursework learning. This quantitative study sought to determine if teacher candidates' self-efficacy increased due to participation in a field-based elementary science methods course with integrated teaching practice consisting of mentoring fifth grade students in investigative science projects. Pretest and posttest STEBI-B data indicate that general (d = .93) and personal (d = .90) science teaching efficacy increased significantly. The increase in outcome expectancy was not significant (d = .38).

Keywords: Self efficacy, preservice teachers, field-based teacher preparation; field-based teaching practice

INTRODUCTION

Teachers' pedagogical competence and their level of teaching efficacy significantly influence the quality of classroom learning (Dana, Campbell, & Lunetta, 1997). Efficacious teaching also reflects the ability to facilitate impactful, active learning experiences (Cone, 2009). The current shift in science education reform calls for a new approach to teaching students in ways that allow them to experience how science is realistically enacted (National Research Council (NRC), 2012). In response to the specific emphasis on engagement in scientific and engineering practices, reform-minded teachers need to plan and implement activities that both stimulate students' scientific curiosity and prepare them to pursue science-related careers. Therefore, elementary students should be provided with abundant opportunities to develop a strong foundation in science to set the groundwork for further learning in the middle level and secondary grades.

Preservice elementary teachers often enter teacher preparation with inaccurate conceptions of science and learning experiences that are not centered on exploration and investigation (Schoon & Boone, 1998; Tekkaya, Cakiroğlu, & Ozkan, 2002). A fear of science teaching may further challenge their learning (Czerniak, 1989). As a result, traditional methods of training prospective teachers may not effectively prime them for the realities of inquiry-based science instruction (Avery & Meyer, 2012). A lecture approach and reliance on the textbook for teaching coupled with endless memorization of facts by students is incompatible with the charge from current science education goals to teach in ways that are grounded in the most effective research on science learning and interdisciplinary inquiry (NGSS Lead States, 2013; NRC, 2012). Prospective teachers need opportunities to confidently develop and implement student-centered instruction that substitutes demonstration of concepts in favor of students' enactment of solid scientific practice (McDermott, Shaffer, & Constantinou, 2000).

Teaching efficacy has been defined as ''the extent to which a teacher believes he or she has the capacity to affect student performance'' (Berman, McLaughlin, Bass-Gould, Pauly, & Zellman, 1977, p. 137), and has been studied in relation to teaching, student learning, and efforts to improve teacher education (e.g., Aston & Webb, 1986; Moore & Esselman, 1992; Ross, 1992). The research on science teaching efficacy suggests that levels of persistence, the degree of risk taking, the choice of instructional strategies and teaching materials, and the willingness to engage in innovative practices are linked to teaching confidence. For example, highly efficacious teachers are more likely to facilitate open-ended inquiry, encourage exploratory learning, use student-centered teaching strategies, and hold beliefs that align with current science education goals (Czerniak, 1989). Teachers with a low sense of efficacy tend to engage in opposite types of behaviors. Czerniak suggests that teacher preparation educators should recognize the behaviors reflecting differing levels of efficacy in preservice teachers and then model behaviors associated with high levels of efficacy. However, this researcher argues that simply identifying efficacy deficits and modeling exemplary behaviors are not sufficient confidence building strategies. Preservice teachers need abundant prospects to practice and develop self-efficacy in realistic teaching environments that field-based teaching practice can provide.

In response to ongoing concerns about what constitutes effective pedagogical preparation, teacher educators are increasingly acknowledging the significance of field experiences to apply what is learned in teacher preparation courses to classroom practice. But simply placing prospective teachers in classrooms is not enough; the quality of classroom practicum and field supervision is essential to the appropriate development of prospective teachers' pedagogical preparation and to building confidence for teaching (Zeichner, 2002). Otherwise, field experiences will become an apprenticeship rather than a reflective, critical experience, and the effect on pedagogical and dispositional development may be negligible (Ohana, 2004).

The purpose of this study was to examine the effect on preservice teachers' efficacy for teaching from a field-based science methods course with integrated teaching practice consisting of mentoring fifth-grade students in investigative science projects. The pedagogical approaches used in the study focus on two critical issues in science education: the need for situated preservice teacher preparation with embedded practical teaching and the need for elementary students to enact scientific practices to build capacity in science learning leading to preparation for middle school and high school science.

THEORETICAL FRAMEWORK

The Construct of Self-Efficacy

Human social function and performance are products of a dynamic interplay between personal, behavioral, and environmental influences (Bandura, 1986). Based on this notion, the concept of self-efficacy beliefs developed primarily from the work of Bandura's social cognitive theory and posits that self-efficacy and behavior are closely related. According to Bandura (1986, 1997), behavior is acquired and regulated through self-efficacy and closely connected to motivation, the exercise of control over action, self-regulation of thought processes, affective states, and physiological states. Self-efficacy is characterized by an individual's belief in his or her capacity to succeed in a given situation by executing behaviors necessary to produce specific performance attainments (Bandura, 1986, 1977, 1997). Thus, self-efficacy is considered to be task specific and differs in this aspect from self-esteem and self-confidence.

Individuals establish their efficacy beliefs from interpreting information from four main sources (Bandura, 1997). Mastery experiences (successful performance), vicarious experiences (observing a person's successful performance), social persuasion (verbal support from others), and emotional arousal (psychological responses such as excitement or anxiety) are thought to be key efficacy determinants of how one thinks, feels, and behaves (Bandura, 1977, 1997). How goals and challenges are approached depend on these major antecedents. Of the four sources, mastery experiences are considered to have the most influence on self-efficacy since they are based on authentic task performance (Bandura, 1977, 1997). Although the vicarious experience is weaker than the mastery experience, it can also contribute significantly to a rise in self-efficacy (Gurvitch & Metzler, 2009).

Self-efficacy beliefs drive human motivation, well-being, and personal accomplishment (Bandura, 1986, 1977). Tschannen-Moran et al. (1998) assert that self-efficacy is related to perceived competence rather than to actual competence. Pajares (2002) points out that unless people believe that their actions will produce desired outcomes, there is little incentive to persist in the face of challenges. Bandura (1997) further contends that efficacy is influenced and malleable predominantly in the early stages of the learning process, suggesting that the experiences of preservice teachers are essential to their subsequent efficacy as practicing teachers. If this contention holds true, then teachers' beliefs about their ability to carry out specific tasks and actions are perhaps most vulnerable and open to influence during student teaching and the first year as a practicing teacher. The importance of influencing teacher efficacy is that improved teacher confidence will likely result in improved student learning (Bandura, 1997).

Woolfolk-Hoy (2000) concluded that the development of teachers' self-efficacy is essential for producing effective, committed and enthusiastic teachers. As well, efficacy beliefs are considered strong predictors of science teaching behavior. Teachers with higher efficacy beliefs are presumed to be able to address and overcome many obstacles by exerting extra effort (Midgley, Feldlaufer, & Eccles, 1989). Their self-efficacy influences persistence, teaching practices, classroom academic focus, time spent on teaching, conceptions of science, and the manner in which they perceive their roles in science teaching (Riggs & Enochs, 1990). Self-efficacy is also related to teacher motivating styles and pedagogical beliefs (Duffin, French, & Patrick, 2012). Teachers with higher efficacy beliefs carve out more time for supporting students to experience different learning activities and addressing learning difficulties. These teacher behaviors, in turn, affect student incentive, persistence, and academic performance (Ashton & Webb, 1986).

Assessment of Science Teaching Efficacy

Bandura (1997) describes self-efficacy as comprised of efficacy expectations and outcome expectations, both of which contribute to teachers' beliefs that effective teaching behavior will positively influence desired learning outcomes. To measure efficacy for science teaching in practicing teachers, Riggs and Enochs (1990) developed the Science Teaching Efficacy Beliefs Instrument (STEBI). Subsequent work on the instrument resulted in the development of the STEBI-B (Enochs & Riggs, 1990) for preservice teachers. Both instruments measure general efficacy for science teaching and yield measures on two subscales of self-efficacy: Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). PSTE measures preservice teachers' beliefs in their ability to effectively teach science, while STOE measures their beliefs that if science is effectively taught, then students will learn. That is, outcome expectancy is the individual's estimate of the likely consequences of performing a task at an expected level of competence (Bandura, 1986). The STEBI-B has been used in numerous studies examining the effects of teacher preparation courses and pedagogical strategies on preservice teachers' teaching efficacy.

Self-Efficacy and Preservice Teachers

Numerous studies (e.g., Bencze & Upton, 2006; Hodson, 2003; Soodak & Podell, 1997) have shown that elementary preservice teachers do not perceive themselves as well equipped for teaching science. Prospective teachers often enter teacher preparation with significant fear of science, negative attitudes and beliefs about science, weak science content knowledge, and weak efficacy for science teaching (Wingfield, Nath, Freeman, & Cohen, 2000). Early detection of low efficacy is critical to effective teacher preparation by implementing timely interventions that address efficacy deficits (Riggs & Enochs, 1990). Unless these deficits are strategically addressed in teacher preparation, preservice teachers will teach in pedagogically unsound ways similar to how they were taught. Helping to overcome their perceived or real fears toward science teaching requires thoughtful incorporation of strategies that address these concerns (Wingfield & Nath, 2000). Careful examination of prospective teachers' background in regard to content knowledge, attitudes toward science, and teaching efficacy are starting points to plan learning experiences that enhance confidence to teach science leading to inspiring and motivating young learners (Bleicher, 2001).

Teacher educators have long recognized the need to advance pedagogical learning in teacher preparation. For example, Professional Development Sites (Wingfield & Nath, 2000) were found to provide preservice teachers with effective modeling, ongoing support, encouragement from mentor teachers and supervisors, and opportunities to engage in classroom teaching. An increase in personal efficacy for teaching was determined through a pretest-posttest administration over two semesters of a modified version of the Science Teaching Efficacy Beliefs Instrument (STEBI-B; Enochs & Riggs, 1990). The increase was conjectured to be due to authentic teaching experiences, vicarious experiences through effective modeling, and positive tones (social persuasion) from peers and mentors. However, the increase in the outcome expectancy subscale did not increase sufficiently to reflect statistical significance.

A two-year mixed methods study by Czerniak and Schriver (1994) of beliefs and behaviors related to self-efficacy revealed that highly efficacious preservice teachers tended to: (a) use more student- centered teaching practices focused on higher level thinking and problem solving; (b) indicate concern for student learning in selecting teaching strategies based on educational theory; (c) use current science education goals in planning instruction; (d) express concern about not being able to provide enough individual attention to students; and (e) focus on their own abilities to influence science learning rather than on external factors. The results of this study corroborate previous findings by Czerniak (1989).

Self-Efficacy and Field Experience Teaching Practice

Authentic field experiences reflect features and characteristics typically found in preschool-12th grade schools. Authentic teaching contexts may be viewed on a continuum from performing in contrived settings bearing little similarity to a school environment (e.g., teaching lessons to university peers in teacher education classes) to performance in realistic contexts (e.g., teaching lessons to elementary students in a classroom). Early and more frequent practicum experiences in teacher preparation are now viewed as “best practice” strategies to potentially influence teaching efficacy (Cochran-Smith & Zeichner, 2005).

Field experiences constitute one of the most essential components of teacher education, as it supports the amalgamation of theory and practice through critical observation and analysis of lessons taught by experienced teachers, but most notably through opportunities to engage in authentic teaching (McDonnough & Matkins, 2010). Fieldwork has the potential to boost preservice teachers’ teaching efficacy, particularly when they realize that they can enhance students’ learning (Dodds, 1989). Conversely, field experiences may also arouse negative emotional states and attitudes, especially if prospective teachers are not adequately supported and trained in the pedagogical complexities of teaching (Tschannen-Moran et al. 1998). Therefore, examining the evolution of preservice teachers’ efficacy beliefs during field practicum may provide insights to causal factors that shape these beliefs during the early learning trajectory in teacher preparation**.**

Personal teaching efficacy may increase in preservice teacher training if certain conditions are in place (Hechter, 2011; Leonard et al., 2011). For example, field experience training and tutoring opportunities have shown to produce significant strides in helping preservice teachers develop the skills and confidence they need to teach in an authentic classroom setting (Cone, 2009; Newman, 1999; Rethlefsen & Park, 2011; Tang, 2003; Zeichner, 2002). Field practicum can also provide preservice teachers with valuable opportunities to gain experience through observation, simulation, mentoring, and small group instruction opportunities, all of which can influence the development of pre-service teachers' efficacy levels and teaching skills (Clift & Brady, 2005). Furthermore, science education methods courses coupled with field experience have been found more effective for developing teacher understanding and efficacy than science content courses (Bleicher, 2001; Watters & Ginns, 2000). Bleicher (2001) argues that teaching methods courses must have self-efficacy development and conceptualized understanding as top priorities in teacher training.

The research on the effects of teaching practice suggests that authentic experiences in teacher preparation exert significant influence on prospective teachers' sense of efficacy (Wingfield, Freeman, & Ramsey, 2000; Wingfield & Nath, 2000; Yilmaz & Çavaş, 2008). Embedded teaching practice in field experiences provides opportunities for prospective teachers to experiment and test their coursework learning and their personal teaching philosophies in a realistic teaching and learning environment (Kabilan & Izzaham, 2008). Gurvitch and Metzler (2009) emphasize that the shift to authentic field experiences from traditional text and lecture methods in teacher preparation has a more profound impact on preservice teachers given the complexities and challenges teachers face in school classrooms.

Field-based training is considered to be a salient benefit in teacher preparation also due to opportunities to build efficacy through performance accomplishments, vicarious experiences, and social persuasion (Bandura, 1997). Comparing pretest-posttest data from the Teacher Efficacy Scale (TES) (Hoy & Woolfolk, 1993), Liaw (2008) found an increase in preservice teachers' personal efficacy mean scores related to motivating students, managing the classroom environment, and selecting teaching resources when placed in elementary schools to teach English through interactive activities. Verbal persuasion during peer discourse on videotaped lessons, vicarious experiences in observing peers' recorded performances, and personal performance accomplishments (Bandura, 1997) during field-based teaching practice were thought to contribute to the increase in personal efficacy. Less clear for Liaw (2008) was the reason for the lack of increase in general efficacy.

Preservice teachers' perceptions of early practicum experiences have been examined in relation to efficacy for teaching. In a study by Li and Zhang (2000) of prospective teachers in field experience, data was gathered from (a) the Teacher Efficacy Scale (Hoy & Woolfolk, 1993), (b) a modified version of the TES for mentor teachers; and (c) a field experience rating scale. Posttest general teaching efficacy scores resulted lower than pretest general teaching efficacy scores. Second, preservice teachers with high ratings of early field experiences had higher posttest personal teaching efficacy scores, while those with low early field experience ratings had lower posttest scores. Third, preservice teachers who rated their cooperating teachers high on efficacy beliefs had higher general teaching efficacy scores, while the converse was found. The authors conjecture with the first finding that early optimism may have been negatively influenced by the realities of classroom demands. The second finding aligns with Bandura's (1997) assertion that one's perception of successful performance and personal accomplishments may raise efficacy beliefs. The third finding supports the notion that mentor teachers may exert significant influence on preservice teachers' attitudes and beliefs (Borko & Mayfield, 1995).

Although strong consensus exists regarding the benefits of field experience, the effects on (a) efficacy beliefs, (b) the development of science teaching skills, and (c) the ability to connect research to practice can differ significantly. Some differences may be attributed to variations in field experience supervision (McDonnough & Matkins, 2010). The researchers studied the influence over four years of embedded practicum in science methods courses that included field-based teaching practice and found that preservice teachers' self-efficacy scores as measured by the STEBI-B (Enochs & Riggs, 1990) consistently increased across all four years when compared to those whose field practicum was not connected to their methods course. In the embedded field experience, the course instructor supervised preservice teachers. Analysis of participants' structured interviews supported the significance of the methods instructor-supervisor as essential to enabling connections of research to classroom practice.

Zach, Harari, and Harari (2012) propose that extending the time spent in practicum field experience will support the knowledge and competencies needed to enhance teaching efficacy called for in actual teaching. Over the span of a four-year teacher preparation program, the authors found a positive correlation between time spent in field experience and general teaching efficacy mean scores. Other studies support the contention that increasing the number of authentic teaching experiences is needed for efficacy to rise and for effective transfer and application of information learned in teacher preparation to teaching students (e.g., Erbas, Kalemoğlu Varol, Erodoğdu, & Ünlü, 2014).

In a study of self-efficacy during teaching practice of preservice teachers, Erbas et al. (2014) administered the Physical Education Teaching Efficacy Scale (Humphries et al., 2012) measuring seven efficacy subscales: content knowledge, applying scientific knowledge in teaching, accommodating skill level differences, teaching students with special needs, instruction, assessment, and technology. Results indicated that efficacy scores related to instruction were highest, while applying scientific knowledge in teaching scores were lowest. Although teaching practice and intensive mentoring were predicted to increase most efficacy subscale scores, the researchers conjectured that specific cultural and psycho-social variables may have accounted for low scores on certain subscales (Erbas et al., 2014).

The research does not yield consensus on how teacher efficacy beliefs develop during preservice education. However, field experiences can provide information on how teaching efficacy develops in specific contexts, and which sources of efficacy inform sense of efficacy (Bandura, 1997). Charalambous, Philippou, and Kyriakides (2007) examined the development of prospective teachers' efficacy beliefs in mathematics teaching during a field experience course that included planning and teaching 30 lessons to elementary students over a three-month period. Quantitative data gathered from the Teachers' Sense of Efficacy Scale (TSES; Tschannen-Moran & Woolfolk Hoy, 2001) and qualitative data from interviews of randomly selected participants revealed that participants evaluated their perceived efficacy with respect to mathematics rather than referring to their general teaching competence**.** Vicarious experiences and social persuasion were conjectured to have affected the development of participants' overall efficacy beliefs.

Capraro, Capraro, and Helfeldt (2010) point out that the research on field experience related to teaching efficacy is not extensive. Although supportive of practicum experiences in teacher preparation, the authors warn that (a) not all field experiences will help bridge the theory to practice gap, (b) simply requiring more field experiences will not necessarily improve teacher preparation, and (c) field experiences may actually increase the incongruence between what is learned in teacher preparation and the reality of what is encountered in authentic classrooms.

Nneji (2013) contends that there is a lack of agreement regarding the influence of teaching practice on preservice teachers' efficacy beliefs. The author examined the effects on the efficacy beliefs of basic science prospective teachers from three public universities during their final year of undergraduate work. Using the Science Teaching Efficacy Beliefs Instrument

(Enochs & Riggs, 1990) in a pretest-posttest study, the researcher found that field experience teaching practice positively impacted efficacy. Nneji conjectures that both personal science teaching efficacy and science teaching outcome expectancy subscale scores increased due to the influence of successful mastery experiences and observing successful teaching models.

Although some studies report an increase in efficacy due to teaching practice, others do not support this finding. For example, Yilmaz and Çavaş (2008) administered a pretest-posttest Science Teaching Efficacy Beliefs Instrument (STEBI-B) to elementary preservice teachers from two universities to determine if their efficacy increased due to teaching practice. The researchers found that almost all preservice teachers' personal science teaching efficacy and science teaching outcome expectancy scores did not increase. The researchers conjecture that prior beliefs and attitudes about science teaching being firmly ingrained before entrance into teacher preparation may have impeded the increase in both subscales.

Despite some preservice teachers possessing well-defined beliefs about their competence, these beliefs may be challenged during teaching practice (Tillema, 2000). In a study on the effects of a student teaching semester on preservice teachers' science teaching efficacy, Plourde (2002) determined that teaching practice did not result in a statistically significant increase in personal science teaching efficacy as determined through the STEBI-B. The semester included science pedagogical strategies learned in a methods course and from mentor teachers in the student teaching practicum (vicarious experiences). As well, study participants were assumed to have significant general pedagogical knowledge and a personal teaching philosophy from the many education courses previously taken in their teacher preparation. Plourde (2002) speculates, like Yilmaz and Çavaş (2008), that the lack of statistical significance could be due to beliefs and attitudes regarding science teaching being firmly set prior to entrance into teacher preparation, and perhaps also due to influences causing deterioration of confidence during student teaching. As a result, Plourde advocates for more research on the effects of student teaching practice on efficacy, as "it seems that this is the genesis of the ineffectual teaching of science" (p. 252).

Research Questions and Hypotheses of the Study

This quantitative pretest-posttest study sought to answer the following questions:

1. Is there an impact on elementary preservice teachers' general science teaching efficacy due to participation in a field-based science methods course with integrated teaching practice?

2. Is there an impact on elementary preservice teachers' personal science teaching efficacy due to participation in a field-based science methods course with integrated teaching practice?

3. Is there an impact on elementary preservice teachers' science teaching outcome expectancy due to participation in a field-based science methods course with integrated teaching practice?

Self-efficacy is believed to be context and subject matter specific (Bandura, 1997; Tschannen-Moran et al., 1998). Based on this conception, teacher candidates' general and personal efficacy for science teaching was hypothesized to increase due to participation in a science methods course with integrated teaching practice. Science teaching outcome expectancy was not hypothesized to either increase or decrease. Previous research studies cited in the theoretical framework of this study indicate that science teaching outcome expectancy may not increase despite an increase in general and/or personal science teaching efficacy.

METHOD

Context of the Study

An elementary school principal from a local district contacted the researcher requesting a meeting in regard to science curriculum enhancement. The administrator expressed a need for more active science learning than what students were currently receiving and requested guidance on how to enrich science instruction. The researcher proposed science mentoring for the fifth-grade student population, a beneficial scaffold given that fifth-graders in California engage in high stakes science testing for the first time in their schooling. The targeted students had no prior experience in formal scientific investigation or opportunities for exploratory learning in the current school curriculum that focused mainly on language arts and mathematics with scant attention to science.

Planning from the perspective of providing onsite professional development for preservice teachers, the researcher recommended that undergraduate teacher candidates mentor students in an inquiry-based, investigative project. The researcher further suggested placing a cohort of candidates weekly on the principal's school campus, a valuable benefit from opportunities to work closely with students in an authentic setting as well as being conducive to the success of the proposed project. A decision was made to dedicate nine weekly, seventy-five minute mentoring sessions with students on inquiry projects. The administrator provided an onsite classroom to accommodate the candidates for the duration of the science methods course. Hence, candidates took credential coursework from the researcher that included training in investigative methods and were then available to work with the school's fifth grade population by the fifth week of the course.

Despite the candidates' teacher preparation program providing adequate professional development, a dilemma prior to the project was that candidates took their coursework on the university campus where there were no opportunities to interact with elementary students in science activities. Fulfilling observation practicum hours intermittently during teacher preparation was not sufficient to expose candidates to the realities and challenges of elementary school science teaching. As Fulp (2002) points out in a report on the status of elementary school science teaching, elementary teachers often express concern with having limited science content knowledge and a lack of confidence to lead science instruction. Considering these rationales, the researcher arranged for teacher candidates to take their science methods coursework in a local elementary school to build teaching efficacy through mentoring fifth-grade students in investigative science.

Although the hosting elementary school pertains to a school district connected to the researcher's teacher preparation program, the school does not participate in teacher preparation. The school's main academic focus is on English language arts and mathematics; science curriculum does not have an equal presence or emphasis. In 2012, the school had a total enrollment of 970 students with 41.9% Latino, 35.3 White, 16.2% Asian, 2.0% Black, and 4.6% distributed among Pacific Islander, American Indian, and two or more races. Forty-one percent of students were classified as socioeconomically disadvantaged, 29.1% were English learners, and 11.1% of students had special needs. Eighty-two percent of students scored at proficient or advanced levels in English language arts, while the percentage for mathematics was 86%. There were no statistics reported for science performance in any grade level.

Participants and Program Design

The participants in this study were a convenience sample of 22 third-year undergraduate students matriculated in a blended teacher education program from a mid-sized, four-year university in Southern California. The teacher candidate participants were enrolled in the researcher's 15-week elementary science methods course in Spring 2012. In general, candidates in the program take courses in subject matter content simultaneously with pedagogical methods courses through collaboration between a Liberal Studies program and the School of Education. Coursework duration is four academic semesters and culminates in a fifth semester of beginning and advanced clinical practice. Candidates fulfill classroom observation hours in the second and fourth semesters of their program. Science methods courses are typically taught in the third semester on the university campus, but for the purpose of this study, teacher candidates were placed onsite at a local elementary school.

Procedures

Preparing Candidates for the Investigative Science Project

The science methods course consisted of subject matter content blended with pedagogical training in science process skills, and curriculum development focused on exploratory science. The investigative science project centered on fifth-grade Investigation and Experimentation standards (science process skills) linked to fifth-grade science content standards (California Department of Education, 2003). The rationale was that the development of process skills in elementary science education is rarely the focus in favor of science content. How scientists enact process skills specific to investigations should be at the heart of science education (National Research Council, 2000, 2012). Therefore, investigative activities requiring the use of scientific procedures and routines provided the focal point for the project.

Fifth-grade students (n = 132) were divided among the 22 teacher candidates so that each mentored six students and two inquiry projects during the nine investigative sessions. Given the project focus, small groups of students chose a specific research question to investigate regardless of science topic, as long as process skills were clearly evident in the activities. The expectation was for students to formulate a reasonable scientific question, plan a course of action to answer the question, and enact scientific practices. The project sought to promote the highest level of classroom inquiry (National Research Council, 2000, p. 29) and critical thinking.

Prior to each project session, class meetings consisted of (a) interactive science activities to build content knowledge, (b) peer teaching activities to develop candidates' pedagogical understanding of science instruction, and (c) a review of session goals. Reference materials were regularly placed on the course management system in the form of tutorials, videos, glossaries, and science content narratives to support inquiry skills and content knowledge development. For all project sessions, overarching guidelines and focusing questions were provided to provoke scientific thinking and habits, active dialogue, and collaboration among students. Candidates were required to access resources and learn the content for discussion and clarification in class meetings. These events were intended to build efficacy to confidently engage with students. Without such supports, the candidates may have had difficulty in providing effective mentorship.

The candidates and their assigned students were divided among six classrooms during the project mentoring sessions. The researcher circulated between these areas to observe progress and to videotape interactions and conversations between the candidates and their students and between students. A debrief discussion with all candidates immediately followed each session during which selected video clips were viewed, discussed, and provided with peer feedback. Candidates were required to write a weekly narrative using specific prompts to reflect on their teaching, student learning, and project progress.

There was no written “script” for candidates to adhere to in the project, as open-ended inquiry is not a scripted endeavor. This initially caused concern for some candidates, but their apprehension lessened over time, as noted progressively in weekly written reflections and in debrief discussions. In general, candidates were consistently encouraged to (a) facilitate student-centered learning, (b) apply their pedagogical learning and knowledge of good teaching from the methods course, and (c) engage the students in higher order thinking and scientific discourse. Table 1 (Appendix A) provides the mentoring project plan and timeline.

Engaging Candidates and Fifth-Grade Students

All mentoring sessions involved teacher candidates and their assigned fifth-grade students working together towards completion of project goals. The initial meeting provided a foundation for the students to engage in scientific thinking by formulating a hypothesis related to constructing an effective paper airplane and then testing and recording data on distance flown. Based on outcomes, students constructed an additional airplane and repeated the process. In subsequent sessions, candidates collaborated with their assigned students to construct a testable research question and hypothesis, identify independent, dependent, and extraneous variables, plan a course of action, and identify required materials to test the hypothesis. Table 2 (Appendix B) reflects a sample of research questions formulated by the student-scientists.

Once the test and retest processes conclusively informed a group’s hypothesis, students finalized details for a written report required to communicate their plan, findings, and conclusions. All student groups were requested to decide on an audience and a presentation method for session nine. Therefore, following the spirit of open-ended inquiry, each student group was permitted to determine its preference related to presentation mode; all student groups came to consensus on the intended audience. Session nine reflected the culmination of students’ work in presenting their project to parents and fourth-grade peers in separate one-hour sessions.

Instrumentation

The Science Teaching Efficacy Belief Instrument-Preservice (STEBI-B) was employed in the present study. Developed by Enochs and Riggs (1990) and based on Bandura’s self-efficacy theory (1977), the STEBI-B is an established and validated instrument that measures science teaching self-efficacy and outcome expectancy in Kindergarten through 12th grade 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 is the belief that an action can be successfully carried out, while STOE asserts that an individual will be motivated to perform a certain action if it is perceived to have a favorable outcome.

The STEBI-B is a 23-item Likert-type instrument with thirteen items measuring PSTE and 10 items measuring STOE. Enochs and Riggs (1990) concluded that the instrument could be considered reliable and reasonably valid with reliability coefficients of .86 and .79 determined for PSTE and STOE, respectively. Since its development in 1990, there were no studies that reexamined the internal validity and reliability of the instrument. However, a study of the instrument by Bleicher (2004) confirmed the basic integrity of the STEBI-B.

The STEBI-B items were prepared in hard copy format for completion by the study participants. A scaled response design 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 value of 5 and Strongly Disagree (SD) having a value of 1. Scores for the PSTE subscale range between 13 and 65, whereas scores for STOE range from 10 to 50. Ten negatively worded STEBI-B items 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 the course following completion of nine investigative science mentoring sessions with fifth-grade students. Candidates' demographic data and previous classroom experience information was gathered at the beginning of the course and is presented in Table 3 (Appendix C).

To answer the three research questions, descriptive statistics were used to analyze and compare the candidates' pretest and posttest STEBI-B scores in regard to general efficacy for science teaching, personal science teaching efficacy (PSTE), and science teaching outcome expectancy (STOE). The researcher hypothesized that 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 integrated teaching practice. Science teaching outcome expectancy (STOE) mean scores were not hypothesized to either increase or decrease.

RESULTS

General Science Teaching Efficacy

A one-tailed dependent samples t-test on STEBI-B general efficacy scores was conducted at the 0.05 level of significance 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 integrated teaching practice. The means of pretest and posttest STEBI-B scores were 82.273 and 88.773 respectively. The results indicated a significant increase in candidates' general efficacy: $t(21) = 2.753$, $p < .05$. The p-value (0.006) suggested a significant difference between the mean scores of candidates' general science teaching efficacy beliefs before and after participation in the course, and the null hypothesis was rejected. Cohen's effect size value (d = .93) suggested high practical significance of the difference between the pretest and posttest general efficacy mean scores. Table 4 (Appendix D) presents the calculated statistics for the first research question.

Personal Science Teaching Efficacy

A one-tailed dependent samples t-test on STEBI-B personal science teaching efficacy (PSTE subscale) scores was conducted at the 0.05 level of significance 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 integrated teaching practice. The means of pretest and posttest scores were 47.636 and 52.727 respectively. The results indicated a significant increase in candidates' PSTE: $t(21) = 3.088$, $p < .05$. The p-value (0.003) suggested a significant difference between candidates' PSTE mean scores before and after participation in the course, and the null hypothesis was rejected. Cohen's effect size value (d = .90) suggested high practical significance of the difference between pretest and posttest PSTE mean scores. Table 5 (Appendix D) presents the calculated statistics for the second research question.

Science Teaching Outcome Expectancy

A two-tailed dependent samples t-test on STEBI-B science teaching outcome expectancy (STOE subscale) scores was conducted at the 0.05 level of significance to determine if there was a difference between teacher candidates' mean scores before and after participation in a field-based science methods course with integrated teaching practice. The means of pretest and posttest scores were 34.636 and 36.045 respectively. The results indicated no significant increase in candidates' STOE mean scores: $t(21) = 1.445$, $p > .05$. The p-value (0.163) verified that there was no statistical difference between pretest and posttest STOE scores. Therefore, the null hypothesis was not rejected. Cohen's effect size value (d = .38) suggested low practical significance of the difference between pretest and posttest STOE mean scores. Table 6 (Appendix D) presents the calculated statistics for the third research question.

Effect Size

Effect size transforms abstract statistical significance testing to a concrete measure of relationship or difference in a way that provides an indication of the magnitude and importance of the findings (Cohen, 1994). In contrast to statistical tests of difference (t-tests) in this study that yielded measures of significance related to whether a field based science methods course with embedded teaching practice impacted candidates' science teaching efficacy, effect size measurements provided a practical methodology to describe the relative magnitude of the experimental treatment (effect). According to benchmark standards of effect sizes, .20 are small effects, 50 are medium effects, and .80 are large effects (Cohen, 1994). Therefore, the large values of d = .93 and d = .90, respectively (based on a comparison of pretest and posttest means on the STEBI-B), indicate a very strong effect of the science methods course on candidates' general and personal science teaching efficacy. A value of d = .38 indicates a small effect on candidates' science teaching outcome expectancy (STOE) from the methods course.

DISCUSSION

There were several collective assumptions gleaned from a review of the literature that guided this study and that lend support to the notion of providing prospective teachers with authentic teaching opportunities and active learning experiences to raise their teaching efficacy. Prospective teachers' persistence, motivation, and classroom performance are affected by how they perceive themselves as teachers and their roles in science teaching (Riggs & Enochs, 1990). Classroom academic focus and teaching practices are influenced by efficacy beliefs (Czerniak & Schriver, 1994). Site-based teacher preparation can provide the four sources of self-efficacy to preservice teachers (Wingfield, Freeman, & Ramsey, 2000). Successful performance and personal accomplishments exert considerable influence on self-efficacy (Bandura, 1986, 1997). Bandura further posits that mastery experiences are the most persuasive source of efficacy information. Mastery experiences should be developed and acquired through field practicum that provides prospective teachers with opportunities to "observe, reflect, create, and carry out inventive approaches to teaching and learning in authentic, diverse settings" (Leonard et al., 2011, p. 148). Integrated field experience courses in teacher preparation can provide preservice teachers with opportunities to gain experiences through observation, simulation, tutoring, and small group instruction opportunities, all of which can influence the development of pre-service teachers' efficacy levels and teaching skills (Clift & Brady, 2005).

This study sought to ascertain if teacher candidates' science teaching confidence would increase in a site-based teacher preparation environment that offered authentic practicum experiences to enhance their pedagogical development. Considering that self-efficacy is assumed to be context specific (Tschannen-Moran et al., 1998), the researcher provided a situated science methods course with abundant opportunities to develop and apply pedagogical and content knowledge acquired through course learning experiences. Prospective teachers in this study were placed in an elementary school for science education coursework and to mentor the fifth-grade student population in investigative science projects. The researcher hypothesized that candidates' general and personal self-efficacy would rise in a learning environment that supported their professional development through nine weeks of teaching practice and mentoring in a school setting. The results of the present study concur with the findings of Wingfield, Nath, et al. (2000), and Davis, Petish, and Smithy (2006) that field-based teacher training may result in significant gains in self-efficacy. The results also lend support to the conception that teaching practice in field experiences provides opportunities for prospective teachers to test their coursework learning in an authentic teaching and learning environment (Kabilan & Izzaham, 2008).

Impact of the Science Methods Course on General Science Teaching Efficacy

In regard to the first research question, the data reflected a significant gain in teacher candidates' general efficacy from the beginning to the end of the science methods course. Mutually beneficial and synergistic collaborations between candidates and their fifth-grade students were conjectured to have contributed to increasing candidates' overall efficacy. Candidates were using teaching practice and mentoring strategies to motivate student interest in science, and students were satisfying their natural curiosity by carrying out investigations using scientific practices. As well, candidates received ongoing, motivating feedback from the classroom teachers on the importance of the critical support that students were receiving in science instruction. The researcher often heard anecdotal comments from the teachers that they did not have time to prepare the kind of student-centered science activities that the candidates provided during the project. Candidates were thus viewed as positive, influential mentors who could incite students to engage in high-level thinking. Interestingly, teachers expressed surprise at the level of engagement that their students were exhibiting during mentoring sessions, including reluctant learners who were traditionally disengaged from regular classroom instruction. These students, like their typical peers, were highly participatory and frequently expressed enjoyment and excitement during project sessions. The researcher conjectures that social (verbal) persuasion given in these contexts contributed strongly to increasing candidates' general teaching efficacy.

Social persuasion from peers was also thought to contribute to overall efficacy from candidates working jointly during course activities and assisting one another to grasp the underlying science concepts. Verbal encouragement and support from the course instructor during these exercises may have further increased general efficacy. Moreover, the instructor modeled exploratory lessons framed by questioning strategies intended to stimulate critical thinking and scientific discourse. Candidates learned to lead and participate in scientific dialogues with peers to prepare for their work with students. These events likely contributed to influencing candidates' efficacy beliefs through the impact that vicarious experiences can exert. As self-efficacy theory posits, observation of an individual successfully modeling a given event generally raises the observer's efficacy beliefs (Bandura, 1977, 1997)**.**

Other course influences were thought to contribute to the rise in general efficacy. For example, candidates were regularly equipped with resources to deepen their understanding of investigative teaching and learning, and timely information related to mentoring project goals. Candidates had ample opportunities to discuss session expectations and targeted student learning outcomes to build teaching confidence. These scaffolds were intended to support their students' dispositional readiness and academic success with respect to their investigative projects. The expectation was that candidates would be well prepared before each mentoring session and thus increase their general efficacy. Hence, learning related to pedagogical strategies, subject matter content, and scientific practices appeared to have had a positive influence on candidates' general efficacy.

Impact of the Science Methods Course on Personal Science Teaching Efficacy

As regards the second research question, the data revealed that teacher candidates' personal science teaching efficacy (PSTE) increased significantly from the beginning to the end of the science methods course. Specific course activities were conjectured to spur the increase in personal efficacy. For example, each candidate worked with another peer to co-plan and co-teach an inquiry lesson framed by "driving" questions. The assignment was intended for the candidate to apply his or her subject matter knowledge and pedagogical learning in relation to creating and practicing skillful questioning strategies that would subsequently serve to guide the fifth-grade students' discourse during mentoring sessions. Each candidate also worked collaboratively with a peer on an "Invention Convention" assignment that was designed to promote enactment of engineering and scientific practices through the creation of a unique product to address a personal or social need. The invention required a written report describing a rationale, ethical concerns, scientific principles involved, materials, production procedures, production costs, a blueprint or model, and a persuasive marketing tool. In addition to fostering scientific thinking and process skills development, the exploratory experience was intended to build personal efficacy for confident engagement with students and to promote career-readiness curriculum.

There were other pedagogical experiences related to course requirements that are assumed to have positively impacted personal efficacy beliefs. For example, science content knowledge was acquired and developed through individual learning experiences. Weekly peer group teaching of assigned readings wherein each candidate taught science subject matter; science concept maps to demonstrate personal evidence of relational understanding; and personal science notebooks with procedures and depictions of instructor and candidates' science lessons were vehicles through which candidates increased science content knowledge on an individual basis. Therefore, an increase in subject matter knowledge focused on conceptual reinforcement likely contributed to building and increasing candidates' personal confidence for teaching.

Personal science teaching efficacy (PSTE) was hypothesized to increase due to mastery experiences and successful performance (Bandura, 1977, 1997) enacted during candidates' individual practice teaching and mentorship of assigned fifth-grade students. Each candidate supported students during the entire process of their open-ended inquiry projects, and guided them through questioning and prompting strategies developed during coursework learning. High-level questions placed before, during, and at closure of each mentoring session were an essential component that sparked critical thinking and interactive scientific discussion between each candidate and his or her students. As well, social persuasion from students during the sessions was another factor that likely contributed to the rise in candidates' PSTE. During debrief meetings after each project session, candidates often cited students' comments reflecting high excitement about their science projects as "super fun", "way cool", and "awesome". Candidates further commented that their student groups looked forward with anticipation to the project work each week. Hence, social persuasion in the form of excitement and compliments from students raised candidates' emotional arousal, which in turn increased feelings of personal competence and mastery (Bandura, 1986, 1997).

Weekly written reflections required after each session generally indicated increasing personal efficacy from the first to the ninth week of the inquiry project experience. Reflecting on teaching performance and adjusting accordingly for subsequent sessions required each candidate to modify and improve pedagogical methods in response to their students' feedback (social persuasion) and project performance.

Candidates' anecdotal comments from the weekly narratives provided useful insights and feedback related to their progress during the investigative science project. As expected, some candidates initially expressed trepidation and anxiety about the expectation of mentoring students in science due to negative experiences in prior science courses.

Samples of excerpted comments in the first three weeks:

"In Session 1, I was literally terrified as I have very little formal experience in teaching science."
"The first session took a really hard hit on me. I don't feel like coming back. I feel so defeated."
"I'm still nervous and wary. I keep telling myself that it'll work out. I just have to try my best."
"I understand that this is not scripted for us for a reason. I'm used to having things spelled out."

Samples of excerpted comments in the last two weeks of the project included:

"I've learned this semester that in science, students should be the ones leading the project."
"I'm pleased how my students got into more divergent thinking and less dependent on me."
"It's exciting to see my students come out of the project with a very positive outlook on science."
"My students' presentations aren't the most professional work, but process skills are excellent!"

It is interesting that comments in the beginning were personal perspectives of challenges in project participation, while those towards the end reflected fifth-grade students' positive learning outcomes and dispositions. Candidates appeared to be more concerned initially with their own lack of knowledge, expertise, and confidence than with their students' lack of experience with investigative science. Initial comments in general reflected a lack of teaching efficacy and frustration while ending comments generally reflected increased personal teaching confidence and positive dispositions about their mentoring experience and about their students' performance in the project.

Impact of the Science Methods Course on Science Teaching Outcome Expectancy

Self-efficacy theory posits that a belief about one's ability to successfully perform an action or behavior is independent of outcome expectancy, a belief that an enacted behavior will likely lead to a specific outcome. Thus, self-efficacy and outcome expectancy have independent effects on behavior change (Maddux, Sherer, & Rogers, 1982). Williams (2010) holds that outcome expectancy is an important predictor of behavioral change. In a teaching and learning context, 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.

With respect to the third research question, outcome expectancy mean scores increased slightly, but the increase was not statistically significant. Therefore, the results align with those found by Wingfield and Nath (2000) and Leonard et al. (2011) in that teaching outcome expectancy did not increase in spite of field-based teacher preparation and despite an increase in teacher candidates' overall and personal science teaching efficacy.

Notwithstanding the indepth pedagogical preparation candidates in this study received prior to and during direct work and teaching practice with students over a nine-week period, their outcome expectancy did not increase significantly from the beginning to the end of their methods course. In contrast, wherein candidates' overall and personal efficacy increased most likely due to (a) indepth pedagogical preparation, (b) indepth science content development, (c) mastery experiences gained through teaching practice with peers and students, (d) vicarious experiences through the instructor's modeling of exploratory lessons, and (e) social persuasion from peers, elementary students, elementary teachers, and the course instructor, these sources of efficacy did not appear to significantly inform or influence candidates' outcome expectancy. This result may be further explained by candidates not believing in their ability to positively influence student learning outcomes, despite their perceived confidence to effectively mentor students in investigative science as an application of coursework learning.

Prior research has shown that outcome expectancy may be resistant to change in spite of instructional contexts. A conjecture offered by Tosun (2000) suggests that a lack of change in outcome expectancy may be attributed to a lack of performance accomplishment in prior science coursework experiences. Maddux, Scherer, and Rogers (1982) contend that outcome expectancy (the results of an action) can influence intention to perform behavior (self-efficacy), but the converse may not occur. In regard to this study, teacher candidates' general and personal self-efficacy appears to not have significantly influenced outcome expectancy, although outcome expectancy may have possibly informed their self-efficacy. This finding concurs with the contention by Maddux et al. (1982) that self-efficacy and outcome expectancy are independent and have independent effects on behavior change.

CONCLUSIONS

Efficacy beliefs are essential components in teacher preparation. The research indicates that field-based teacher preparation may strongly influence science teaching efficacy beliefs (e.g., Wingfield & Nath, 2000). Field experiences should aim to serve as a conduit between the theoretical components of formal teacher preparation and the practical realities of teaching (Dodds, 1989). In addition, methods courses have the ability to positively impact the practice of beginning teachers and provide strong conditions for preservice teachers' professional development if linked to elementary school practices (Castle, Fox, & Souder, 2006). As this study has shown, carefully structured field experiences in teacher preparation that include practical teaching can provide strong prospects for connecting theory to classroom practice while simultaneously influencing efficacy beliefs.

The research on preservice and early inservice teaching reveals that the realities and challenges of classroom demands may either impede efficacy beliefs to rise or may contribute to a decrease. The preservice teachers in this study entered their science methods course with a range of science teaching efficacy beliefs as evidenced by the pretest general and personal efficacy STEBI-B data. Participation in a course that afforded them support and opportunities to mentor students in investigative science appeared to have positively contributed to their expectations of proficient teaching performance.

To ensure that preservice teachers are provided with appropriate mastery and vicarious experiences during teacher preparation, science teacher educators should plan integrated approaches in field-based methods courses that facilitate impactful learning with the capacity to raise efficacy beliefs. The researcher contends that integrated teaching practice as a course requirement contributed to an increase in overall and personal efficacy in this study because, after all, the candidates' mentorship of students was a direct application of their coursework learning.

Although general and personal science teaching efficacy increased significantly in the present study, outcome expectancy did not significantly rise. While preservice teachers may believe in their capacity to effectively teach science, their belief in the ability to influence student learning is less definite. Further studies should focus on examining the development and trajectory of outcome expectancy in teacher preparation. As well, future research is warranted to ascertain how efficacy beliefs influence teaching practice leading to student achievement.

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Appendix A

Table 1

Plan and Timeline for Fifth-Grade Investigative Science Mentoring Project

Session No.	Activities and Tasks
1	Introduction of candidates to their two groups of 5th grade students Focus: What is science? How can you answer a research question? Inquiry Activity: What shape of paper airplane will fly the farthest distance?
2	Developing a research topic: Brainstorming ideas leading to research development Formulating a research question and developing a hypothesis Identifying dependent and independent variables
3	Thinking through and devising a plan (experiment) to test the hypothesis Science process skills and the scientific method Generate a list of materials needed to set up and test each group's hypothesis.
4	Review, refine, and record experimental plan. Test hypothesis, collect and record observations and data. Analyze the results. Retest hypothesis and refine hypothesis if needed.
5	Retest hypothesis from session 4 to determine if results are replicated. Collect and record observations and data. Analyze the results and accept or reject the hypothesis. Refine hypothesis or plan? Are a new question and hypothesis needed?
6	Candidates and students work to finalize details of the project to prepare for written report using recorded information, data, and results. Finalize project if not completed in session 5.
7	Student groups work on written report in computer lab or on classroom computers. Students decide on presentation audience and method of presentation,
8	Candidates review their groups' completed reports for submission to students' fifth-grade teachers. Students work on a digital presentation or trifold poster in preparation for oral presentations.
9	Candidates and students set up final research project presentations in designated classrooms and computer lab.

Students present projects to parents and fourth-grade peers in separate sessions.

Appendix B

Table 2

Sample of Fifth-Grade Students' Investigative Science Project Research Questions

Is sound pitch in a closed container affected by the amount of air in the container?

Does balloon size affect the distance that a balloon rocket will travel?

Do all family members have the same category of fingerprint?

Is there a difference between our 5th grade boys and girls in the number of monthly homework hours accomplished?

Is there a relationship between human index finger length and forearm length?

What house color and shape combination produce the most effective insulation?

Is eye color related to the ability to identify colors?

What is the best insulator to ensure that an egg does not break from a 10-foot drop?

Does the shape of an object affect how far it can be thrown?

Does the amount of Play-Doh used in a squishy circuit affect the brightness of an LED?

For a given area, what shape produces the largest volume of a floating container?

Does the amount of air in a balloon affect how long it stays in the air?

Do right-handed people and left-handed people have different response times?

Does light affect plant growth in the same way regardless of a plant's position?

Does the sole of a tennis shoe make a difference in running time across the schoolyard?

Does jump rope length affect the number of successful jumps accomplished in one minute?

Does water quality affect the growth of radish plants?

Does colored cellophane placed on plant leaves affect the rate of leaf and plant growth?

Does a quarter sink at the same speed in different liquids?

Does whole wheat bread produce mold faster than white bread?

Appendix C

Table 3

Teacher Candidate Demographic Information (n = 22)

Gender		
Male	Female	
2	20	
Age		
Under 25 years	25 – 29 years	30 – 39 years
18	1	3
Previous Teaching or Classroom Experience		
Yes	No	
18	4	
Years of Previous Teaching or Classroom Experience		
0-1 years	2-3 years	4-5 years
13	3	6

Appendix D

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

	Pretest Scores	Posttest Scores
Mean	82.273	88.773
Variance	51.827	51.136
Observations	22	22
S.D.	7.199	7.151
t	2.753	
p-value	0.006	
t critical (one-tail)	1.721	
Cohen’s d	.93	

Table 5
t-Test Paired Two Sample for Means (STEBI-B Personal Science Teaching Efficacy)

	Pretest PSTE Scores	Posttest PSTE Scores
Mean	47.636	52.727
Variance	45.004	21.541
Observations	22	22
S.D.	6.709	4.641
t	3.088	
p-value	0.003	
t critical (one-tail)	1.721	
Cohen’s d	.90	

Table 6
t-Test Paired Two Sample for Means (STEBI-B Science Teaching Outcome Expectancy)

	Pretest STOE Scores	Posttest STOE Scores
Mean	34.636	36.045

Variance	10.052	19.188
Observations	22	22
S.D.	3.170	4.380
t	1.445	
p-value	0.163	
t-critical (two-tail)	2.080	
Cohen's d	.38	