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INQUIRING INTO MY SCIENCE TEACHING THROUGH ACTION RESEARCH: A CASE STUDY ON ONE PRE-SERVICE TEACHER'S INQUIRY-BASED SCIENCE TEACHING AND SELF-EFFICACY

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ABSTRACT. This case study reports the effects of a cooperative learning field experience on a pre-service teacher's views of inquiry-based science and her science teaching self-efficacy. Framed by an action research model, this study examined (a) the pre-service teacher's developing understanding of inquiry-based science teaching and learning throughout the planning and implementation phases of the field experience and (b) the pre-service teacher's inquiry-based science teaching self-efficacy beliefs prior to and after the field experience. The pre-service teacher's self-reflections before and after the field experience, video reflections, and results from the Personal Science Teaching Efficacy, a subscale on the Science Teaching Expectancy Belief Instrument-form B, were analyzed in this study. The findings revealed that (a) the pre-service teacher's understanding of inquiry-based science teaching and learning was developed and enhanced through the planning and teaching phases of the field experience and (b) the pre-service teacher's science teaching self-efficacy beliefs were improved as a result of a stronger appreciation and understanding of inquiry-based science teaching and learning. Further, the significance of this study suggests the use of cooperative inquiry-based field experiences and pre-service teacher action research by teacher education programs as means to deepening understanding of inquiry-based science instruction and increasing self-efficacy for such teaching.

KEY WORDS: action research, field experience, inquiry-based science teaching and learning, pre-service teacher, self-efficacy beliefs

Objectives

The purpose of this study is to examine the effects of a cooperative learning field experience on a pre-service teacher's views of inquiry-based science and her science teaching self-efficacy. Research questions include: (a) What is the pre-service teacher's understanding of inquiry-based science throughout the planning and implementation phases of the field-experience? and (b) How do the pre-service teacher's science teaching self-efficacy beliefs prior to and after the field experience compare?

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Theoretical Framework and Literature Review

Action Research

As defined by Kemmis (1982), "action research in education is a term used to describe a family of activities in curriculum development, professional development, school improvement programs, and systems planning and policy development" (as cited in Parsons & Reynolds, 1995, p. 3). No matter the focus, Kemmis (1982) indicates that "action research aims to improve in three areas: the practice, the understanding of the practice by its practitioners, and the situation in which the practice takes place" (as cited in Parsons & Reynolds, 1995, p. 4). Moreover, teachers can conduct action research projects to actually test a teaching strategy, instructional materials, or curricula with their students to track their effectiveness (Akerson & McDuffie, 2002; Cullen, Akerson & Hanson, 2010).

Most teachers regularly examine and reflect upon their practices as part of their usual teaching procedures. Briscoe and Wells (2002) and Lytle and Cochran-Smith (1990) indicate that "action research can bridge the gap between theory and practice because it helps teachers to understand the purpose of educational research and in turn, informs educational theory of the reality of the classroom" (as cited in Kang, 1997, p. 472). Similarly, Akerson & McDuffie (2002) further describe action research as "inquiry into one's own teaching," as it "promises to give teachers an authentic experience in inquiry on their own science teaching as a professional development tool" (p. 5).

Many teacher–researchers have identified the benefits of action research in the classroom to include heightened self efficacy, increased reflection and responsiveness, and enhanced motivation for teaching (Megowan-Romanowicz, 2010; Cullen et al., 2010; Lebak & Tinsley, 2010). Furthermore, in a study examining the effects of a teacher–action research professional development program, Cullen et al. (2010) reported that teachers had an improved view of themselves as teachers after conducting action research on their classroom instruction. They also noticed that after the action research, teachers were more inclined to advocate for themselves and their students.

Just as it benefits in-service teachers, action research is a helpful tool for pre-service teachers to explore and learn new teaching methods, as they regularly monitor the effectiveness of their developing teaching practices. Capobianco & Feldman (2010) stress that it is important for teachers to adjust to the ongoing standards and accountability changes in

science education. They suggest that pre-service teacher action research could serve as a viable means to both address and embrace these changes. Capobianco & Feldman (2010) further indicate that the " …role of scientific inquiry, scientific research practices, and evident-based claims in the science classroom are just a few examples of the changing landscape in science education" (p. 913). They claim that addressing these changes through action research will make teacher experiences and practices more visible and open to analysis, providing constructive avenues for educational change. Similarly, Goodnough (2010) notes that through action research, pre-service and in-service teachers become "researchers and knowledge creators, engaging in systematic inquiry into their own experience and critically using formal knowledge to inform their inquiry and help interpret findings" (p. 920).

Studies examining the benefits of pre-service action research claim that it is a necessary component to preparing teachers to be effective practitioners (Capobianco & Feldman, 2010; Goodnough, 2010; Megowan-Romanowicz, 2010; National Research Council, 2000). However, pre-service action research studies have not received as much attention as in-service ones. The addition of studies from the direct point of view of the pre-service teacher may provide valuable insight into the effectiveness of teacher education programs.

Inquiry-Based Science

Akerson & McDuffie (2002) define inquiry as "raising an investigable question, developing methods to answer that question, carrying out those methods, analyzing the data, and reporting the findings and making conclusions" (p. 3). The National Science Education Standards (National Research Council, 1996) emphasizes the importance of scientific inquiry by including specific content standards on inquiry abilities and understanding of inquiry. The Standards indicate that:

> Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as understanding of how scientists study the natural world. (p. 23)

Bleicher & Lindgren (2005) claim that providing the time necessary for students to "see science" and "do science" is the most important factor in developing their understanding (p. 214). The importance of guided inquiry, especially at the introductory level, is such that it helps students develop knowledge and conceptual understanding. This understanding

allows students to dig more deeply into key ideas (National Research Council, 2000). By observing the changes in student achievement and the classroom environment after inquiry-based teaching is implemented, teachers can initiate changes according to their curriculum or school policies (Goodnough, 2010).

For inquiry instruction to be effective, however, teachers must first experience inquiry-based approaches. The National Research Council (2000) indicates that, "pre-service or graduate courses and in-service workshops are …the most prevalent formats for teachers to develop and improve their inquiry teaching" (p. 104). Accordingly, it is crucial for teacher education programs to embrace an instructional inquiry-based sequence (National Research Council, 2000). Without formal experience in inquiry-based teaching and learning in teacher preparation programs, in-service teachers either omit inquiry-based teaching or rely on professional development programs to gain an understanding of inquiry-based science (Lebak & Tinsley, 2010; National Research Council, 2000). Ensuring that teachers are confident in their inquiry-based teaching methods will help address the science literacy needs of all students (National Research Council, 2000).

Self-Efficacy

Bandura (1997) defined self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). Recent studies have suggested that pre-service teachers' level of science teaching self-efficacy tends to be low but can be substantially increased after taking a science methods course (Gunning & Mensah, 2011; Hechter, 2010; Palmer, 2006). In order to address the lower levels of science teaching self-efficacy of many pre-service teachers, researchers have indicated the importance of structuring teacher education programs to directly support self-efficacy development (Gunning & Mensah, 2010; Hechter, 2010). There is a multitude of ways to improve teacher education programs to focus on developing pre-service teacher science teaching self-efficacy. Gunning & Mensah (2010) suggest that support for pre-service teachers such as discussions, urban field experiences, and interacting with other teacher candidates and in-service teachers early on in teacher education programs are important elements to be included in teacher preparation programs to foster the development of pre-service teacher's science teaching self-efficacy.

In addition to well-developed, positive pre-service teacher methods courses, Hechter (2010) argues that structuring science content courses to

engage pre-service teachers in the same positive experiences that they will later lean how to implement in their own classrooms will also increase pre-service teachers' science teaching self-efficacy. According to Hechter (2010), making connections between post-secondary science content courses and science teaching methods courses will raise pre-service teachers' levels of science teaching self-efficacy (p. 199).

Methods

Setting

The setting for this action research study was a cooperative learning field experience within an undergraduate science methods course. The field experience took place in a program called *Saturday Ocean Sciences Institute* at a liberal arts university in the northeast. Twenty-one pre-service teachers, forming four cooperative groups, developed a 4-week ocean sciences unit. During the 4-week institute, elementary students came to the university on Saturday mornings to participate in hands-on, "minds-on" science activities exploring ocean sciences. During the planning stages of this institute, one pre-service teacher became interested in the ways this experience affected her views of inquiry-based science and her own self-efficacy with respect to teaching science. This action research was developed as a means of professional development and further inquiry into her own practices.

The pre-service teacher who conducted this action research study was in her second year of undergraduate studies. This field experience took place during the second-semester of a year-long methods course focused on understanding and teaching inquiry-based science in elementary school classrooms.

The pre-service teacher, who is the central focus of this study, co-planned and co-taught all three lessons with her cooperative group members. The data collected through her action research pertains to the planning, implementation, and reflection phases of this experience. Data reported within this case study specifically highlights her personal experiences planning, teaching, and reflecting throughout the process.

Working within a collaborative field experience allowed the pre-service teacher to receive input and assistance from her team members. The co-teaching model was structured so the elementary school students were assigned to groups. Each co-teacher taught a group of six to eight students for most of the field experience. In addition to carrying out

lessons and activities, the pre-service teacher was also the lead teacher in a series of discussions with the whole class after two of the three lessons. During the remaining lesson, the pre-service teacher assisted the lead teacher during the whole-class discussion. All of the data collected in this study directly reflects the practice of the pre-service teacher. These data explicitly represent her views and practices of inquiry-based teaching, as well as her science teaching self-efficacy throughout the field experience. All data collected pertain specifically to the lessons during which the pre-service teacher lead the whole class or a small group.

Data Sources. Data sources for this study include written self-reflections, video recordings of teachingm and completed Science Teaching Efficacy Beliefs Inventory (STEBI-B) forms. The pre-service teacher kept a journal of reflections throughout the planning phase. Prior to implementation, the pre-service teacher referred to this journal to create a comprehensive self-reflection. This reflection captured the pre-service teacher's understandings of inquiry-based science and beliefs of science teaching self-efficacy that she developed while planning the field experience.

One post-teaching reflection was written which captures the pre-service teacher's thoughts immediately following the teaching experience. Both comprehensive reflections were used to compare the pre-service teacher's science teaching self-efficacy beliefs and understanding of inquiry-based science before and after teaching.

Self-reflections and video recordings were analyzed based on the techniques developed by Strauss & Corbin (1990). The pre-service teacher and her science methods course instructor were first engaged in analysis of the reflections and video recordings individually. Statements within the reflections were coded as either indicative of instructional commendation/success or of challenges/difficulties in the following areas: (1) understanding of inquiry-based science teaching and learning and (2) science teaching and learning self-efficacy beliefs. Video recordings of the pre-service teacher's teaching experience were viewed and analyzed to reflect on how she practiced inquiry-based teaching in the *Saturday Ocean Sciences Institute*. A coding system based off of the variations of the Five Essential Features of Inquiry Teaching and Learning Across All Grade Levels (National Research Council, 2000) was used to code the video reflection. Each essential feature of inquiry is accompanied by four variations that differ based on the amount of learner self-direction and teacher guidance incorporated into the lesson (National Research Council, 2000). A two-digit code (e.g. 1–1) was assigned to an identified teaching/

learning situation that exemplifies a variation associated with one of the essential features of inquiry. The first digit of the code specifies which essential feature was observed in the following way:

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

The second digit of the code indicates the variation associated with the identified essential feature with 1 being most teacher guided and 4 being most learner self-directed.

Following the individual analysis of the reflections and video recordings, the researchers shared their preliminary analysis to triangulate their coding by "reading, rereading, and reflecting upon the significant statements" in the reflections (Creswell, 1998, p. 281) and reviewing the important segments of the video recordings. Lastly, each researcher reviewed the triangulated coding as a final validation.

In addition, the Personal Science Teaching Efficacy (PSTE) was implemented once during the planning stages and once immediately following the teaching experience. PSTE is a subscale measured in 13 of the 23 items on the STEBI-B designed by Enochs & Riggs (1990). Data collected from PSTE were analyzed by comparing the results before and after teaching to identify any changes, if any, in the pre-service teacher's belief regarding her own ability to teach science effectively (Enochs & Riggs, 1990). The change was coded positive, negative, or neutral for the pre-service teacher's increased, decreased, or same level of PSTE, respectively.

Results and Discussion

Understanding of Inquiry-Based Science Teaching and Learning

Self-Reflections. Reflections were analyzed by comparing the number statements that were indicative of success in teaching and implementation to the number of statements that were indicative of instructional/pedagogical challenges or difficulties that were written before and after teaching.

The biggest challenge noted prior to teaching was choosing the appropriate inquiry activities. The team teachers had many ideas, but most

were not inquiry based. Being able to shift activities to be more inquiry-based suggests that the pre-service teacher had at least a basic understanding of the characteristics of an inquiry-based lesson.

The post-teaching reflection analysis revealed many statements that reflected success in implementation which specifically referred to the pre-service teacher's experiences with new inquiry-based teaching methods. Specifically, the pre-service teacher suggests that guiding and questioning students is helpful in monitoring student learning and understanding. This statement implies that the pre-service teacher has discovered that she can facilitate students' inquiry by guiding the learning experience with open-ended questions, such as "Raise your hand if you can tell me how you think people have a negative effect. What happens when people pollute water?"

In addition, the pre-service teacher indicated that she had to think quickly while teaching to ask engaging questions that met the needs of her students. This realization suggests that the pre-service teacher has found that active reflection while teaching, as a means of formative assessment, not only improves students' understanding but benefits her own development as a teacher as well.

The post-teaching statement that indicated instructional challenges was in reference to an activity that was not implemented as planned. The pre-service teacher overestimated students' prior knowledge and writing skills, which altered the course of the activity. Although this occurrence posed a challenge during the lesson, the pre-service teacher adjusted the lesson format to be more teacher-directed as the students did not have the prior knowledge to engage in in-depth conversations. This reflection demonstrates the importance of being able to shift activities and pedagogical approaches so that student's needs are met.

Video Reflection. Video recordings of the three lessons where the pre-service teacher taught or assisted the teaching of the other team members were analyzed. The first lesson, *Acidic Oceans*, engaged students in an activity that explored the effects of varying concentrations of an acidic solution (water and vinegar) on various calcium carbonate materials (antacid tablets, pieces of chalk, and seashells). Students tested the effects that vinegar and water solutions had on these materials as a means of investigating the impact of acid pollution in the ocean.

The second lesson was a whole-class follow-up discussion about the negative effects of different sources of pollution. The teacher

facilitated the students' discussion to create a cause-and-effect web pertaining to ocean pollution. Finally, in the third lesson, students applied what they learned throughout the *Saturday Ocean Sciences Institute* to create their own marine species. Students were encouraged to use the science journals they had kept and handouts received over the past weeks to guide their creation process. Teachers facilitated the lesson by asking probing questions to help students clarify and justify the design of their new species, such as a specific color chosen for the purpose of camouflage.

Videos of these lessons were reviewed to examine how the pre-service teacher practiced inquiry-based teaching in the *Saturday Ocean Sciences Institute*. Table 1 displays the variations of the essential features of inquiry observed though video analysis of the pre-service teacher's lessons.

Video reflection and analysis revealed that the pre-service teacher incorporated teaching strategies that enabled students to experience variations of all five essential features of inquiry within the teaching experience. The results of the video analysis show that the pre-service teacher mostly incorporated variations that were either strictly teacher-guided or strictly learner self-directed.

The teacher-guided aspects of the teaching experience included features of inquiry that were based on questioning and making connections. In terms of questioning, the pre-service teacher and the materials supplied by the pre-service teacher provided the questions in which the students were engaged. Students were provided with guiding questions for their activities and the pre-service teacher engaged students in discussions with guiding questions, such as "How can something like acid rain affect the sea creatures based on what you've seen here?"

Making connections was also a teacher-guided feature of this teaching experience. Video analysis indicated that the learners were told most of the connections between the classroom activities and other scientific knowledge. After undergoing an experiment about acidic oceans, students were shown a video clip about how forms of pollution affect pollution. This also acted as a visual aid for students; however, students themselves did not extrapolate the connections themselves. In addition, the pre-service teacher facilitated various discussions and reminded students of important appropriate scientific vocabulary. Thus, the pre-service teacher gave the scientific connections to the students visually and aurally, which in turn facilitated more class discussions about the topic. Overall, the teacher-guided

TABLE 1

Variations of the essential features of inquiry observed through video analysis of the pre-service teacher's lessons

Essential features	*Examples (codes)*
1. Learner engages in scientifically oriented question.	"What do you see? Has anything changed?" (1–4) *Lesson 1* "Tell us what you found …What happened to your object when you put it in the polluted, very polluted and clean water?" (1–4) *Lesson 1* "How can something like acid rain affect the sea creatures based on what you've seen here?" (1–4) Lesson 1 "Raise your hand if you can tell me how you think people have a negative effect. What happens when people pollute water?" (1–4) *Lesson 2*
2. Learner gives priority to EVIDENCE in responding to questions.	Students are provided with materials and worksheets that guide them in recording observations. (2–2) *Lesson 1* "You can make your observations in these boxes …touch [the chalk], smell it …" (2–2) *Lesson 1* One student claimed, "We noticed that when we put chalk in the 'very polluted' water …it dissolved quicker." (2–2) *Lesson 1* "At first, there was a crack and the crack started to make air come out and chemicals. And then when we did it the second time …it started to make very big cracks …little particles started to keep coming and coming …and the last one … everything went right on it …and it dissolved … it's almost like eating it."[a]—Student (2–1) *Lesson 1*
3. Learner formulates EXPLANATIONS from evidence.	"When we had the medicine in the water …it was changing, like the chemicals were coming out and spreading around in the water, so probably, if you put medicine in the water where the ocean [and] …fish is, they might die."[a]—Student (3–1) :*Lesson 1*
4. Learner connects explanations to scientific knowledge.	"Antacid tablets are actually made out of some of the same substances that are in seashells." (4–4) *Lesson 1* "Acid rain comes from all those gases we see coming from cars …that get up into the clouds and contaminate …they make the cloud all dirty. And when it rains, that dirty gas gets into the water and falls into the ocean …So, the vinegar

TABLE 1 (continued)

	is very similar to that dirt gas called CO_2 which gets into the water." (4–4) *Lesson 1*
5. Learner communicates and justifies explanations	Throughout the activity, the pre-service teacher continually urged students to, "Talk to each other." (5–2) *Lesson 1* "Tell us what object you had and what happened to it" (5–3) *Lesson 1* "When we had the medicine in the water …it was changing, like the chemicals were coming out and spreading around in the water, so probably, if you put medicine in the water where the ocean [and] …fish is, they might die."[a] (5–1) *Lesson 1*

[a]These comments were made by the fourth-grade students.

aspects of this field experience indicate that the pre-service teacher was able to provide guidance throughout the lessons by facilitating discussions and providing experiences for students to visually make connections.

The remaining three essential features of inquiry in this lesson were learner-self directed. These essential features include giving priority to evidence when responding to questions, formulating explanations, and communicating explanations. The video analysis showed that throughout the teaching experience, students were making observations and recording what they determined was important evidence of the reactions taking place. As Table 1 shows, students decided that an important observation was that the piece of chalk was dissolving in the "very polluted" water. The pre-service teacher provided students with guiding questions and the students determined what the appropriate evidence was to answer the questions regarding the experiment.

Video analysis also indicated that students mostly formulated explanations individually, based on the evidence that they recorded. For example, in describing the results of the *Acidic Oceans* activity, a student responded, "When we had the medicine in the water …it was changing, like the chemicals were coming out and spreading around in the water, so probably, if you put medicine in the water where the ocean [and] …fish is, they might die." Because the pre-service teacher allowed the students to determine what they believed constituted

evidence, the students were able to understand and describe the reactions taking place in the experiments.

Finally, the video analysis indicated that communication was also learner self-directed. As students were able to collect evidence and formulate their own explanations, they were prepared to form logical arguments to communicate their explanations. Student contributions to class discussions were detailed, as summarized in Table 1. This evidence of learner self-directed communication is another indication of successful implementation of inquiry-based science in this teaching experience.

Over all, the learner self-directed features of inquiry in this lesson were successfully implemented in the sense that students were able to use their science process skills—observing, predicting, inferring, and ultimately communicating their logically formulated explanations of the experiment to the class. In combination with the teacher-guided features of inquiry in this teaching experience, the essential features of inquiry were implemented in such a way that provided an engaging and interactive learning environment for the students.

Researcher's Science Teaching Self-Efficacy

Self-Reflections. Reflections were analyzed by comparing the number statements that were indicative of success in teaching and implementation to the number of statements that were indicative of instructional/pedagogical challenges or difficulties that were written before and after teaching. Table 2 displays this comparison.

Before teaching, the pre-service teacher indicated being apprehensive about her self-efficacy. At the very beginning of the planning phase, she noted being intimidated by planning science lessons. Once into the planning phase, she also indicated being uncertain of her abilities to implement her lessons effectively. This suggests that although the pre-service teacher indicated understanding of inquiry-based teaching, having little experience implementing inquiry-based teaching methods prior to this experience may have caused self-doubt and poor self-efficacy.

As the pre-service teacher saw her efforts materialize into concrete lesson plans, she became more confident in her teaching practices. This indicates that the final product was a reminder of the pre-service teacher's understanding of inquiry-based science, suggesting that the realization of her own knowledge positively impacted her science teaching self-efficacy.

TABLE 2

Comparison of statements indicative of commendations/successes in teaching to statements indicative of instructional/pedagogical challenges or difficulties from the before and after teaching reflections regarding self-efficacy

Teaching reflection	*Commendation/success in teaching*	*Instructional/pedagogical challenges or difficulties*
Before teaching	Seeing all of our efforts finally come together at the end of the planning stage certainly made me more confident to teach these lessons.	My team members and I all seem to have some level of apprehension about our teaching abilities. At first thought, the idea of planning and implementing a 3-h long science institute is a little intimidating.
After teaching	The feedback I received from students gave me more confidence to carry on during the lesson. My teaching experience built up my confidence by forcing me to learn through experience. Becoming comfortable implementing various inquiry-based teaching strategies has made me a better teacher.	Sometimes students struggled with writing responses and I was unsure of how to balance facilitating time between grammar/sentence composition and questioning for understanding of the science concepts.

Analysis of the post-teaching reflection reveals that the majority of commendations of teaching/implementation pertain to ways that the pre-service teacher heightened her self-confidence in teaching science. This includes receiving feedback from students and team teachers as well as gaining experience implementing inquiry-based teaching methods. This indicates that the pre-service teacher's self-efficacy was positively affected by critical feedback and first-hand experience.

The only statement that reflected instructional difficulties referred to the pre-service teacher's uncertainty of effective strategies to integrate writing and science without losing sight of the science content. This uncertainty led to a learning experience where she was left to alter her teaching methods to facilitate the students' learning. The post-teaching reflection indicates suggestions such as "allowing students to draw pictures, or giving students key words to use helped to accommodate those students who had more difficulty writing." This reflection suggests the importance of utilizing adaptive and accommodative strategies while

teaching in order to reach out to all students. Although this occurrence was seen as a challenge for the pre-service teacher, it ultimately benefited her self-efficacy as she realized the importance of and her ability to use adaptive teaching strategies. Overall, the pre-service teacher's statements reflected growth in her self-efficacy beliefs throughout the entire planning and implementation phase of the teaching experience.

PSTE. The PSTE subscale allows the pre-service teacher to rate statements concerning self-efficacy from "strongly agree" down to "strongly disagree." Table 3 compares the PSTE results before and after teaching.

Before teaching, the pre-service teacher felt most confident in her belief that she would continually find new ways to teach science and reach out to underachieving students. Item numbers 1, 4, 9, and 11 indicated these strong beliefs. Thus, she felt most confident in her self-improvement abilities and showed confidence in finding new ways to help students learn. She felt least confident in her science content knowledge and abilities to deliver an effective lesson before teaching. Item numbers 3, 5, and 12 indicate this belief. These items also indicate uncertainty in effectively teaching science compared to other subjects.

After teaching, the pre-service teacher felt most confident with increasing her efforts to find new teaching procedures to help student achievement. Item numbers 2, 4, and 13 indicate these beliefs. Her most confident beliefs before and after teaching were similar, indicating a heightened level of self-confidence for finding effective teaching methods.

The pre-service teacher indicated that she is uncertain that underachieving in science is due to poor teaching prior to teaching but changed her response to "agree" after teaching; however, she does not strongly agree with this statement. Similarly, she agreed that the low science achievement of some students could not generally be blamed on the teacher both before and after teaching. These results indicate that she is not completely confident that she could help every student reach proficiency in science. The possibility of other factors interfering with a student's learning is one possible reason for not responding to these questions with an absolute.

After implementation, the pre-service teacher's belief that changed most significantly was item number 3, which indicates her heightened level of self-confidence in teaching science effectively in comparison to other subjects. The mostly positive changes revealed by the PSTE further justify her boosted confidence in her science teaching self-efficacy beliefs.

TABLE 3

Comparison of PSTE results taken before and after teaching

Item	*Before teaching response*	*After teaching response*	*Change in self-efficacy*
1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	Undecided	Agree	Positive
2. I will continually find better ways to teach science.	Agree	Strongly agree	Positive
3. Even if I try very hard, I will not teach science as well as I will most subjects.	Undecided	Strongly disagree	Positive
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	Agree	Strongly agree	Positive
5. I know the steps necessary to teach science concepts effectively.	Undecided	Agree	Positive
6. I will not be very effective in monitoring science experiments.	Disagree	Strongly disagree	Positive
7. If students are underachieving in science, it is most likely due to ineffective science teaching.	Uncertain	Agree	Positive
8. I will generally teach science ineffectively.	Disagree	Strongly disagree	Positive
9. The inadequacy of a student's science background can be overcome by good teaching.	Agree	Strongly agree	Positive
10. The low science achievement of some students cannot generally be blamed on their teachers.	Agree	Agree	Neutral
11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	Agree	Agree	Neutral
12. I understand science concepts well enough to be effective in teaching elementary science.	Uncertain	Agree	Positive
13. Increased effort in science teaching produces little change in some students' science achievement.	Uncertain	Disagree	Positive

Conclusion

The findings revealed that (a) the pre-service teacher's understanding of inquiry-based science teaching and learning were developed and enhanced through the planning phase and teaching phase of the field

experience, which increased her abilities to implement inquiry-based activities and improve them as well, and (b) the pre-service teacher's science teaching self-efficacy beliefs improved resulting in a high level of self-confidence in teaching science as effectively as other subjects.

A convergent theme between the before teaching reflections and the prior to teaching STEBI-B survey indicates that the pre-service teacher was apprehensive about her abilities to implement an effective science lesson. The data retrieved prior to the teaching experience also indicate that the pre-service teacher was confident in her abilities to improve upon her teaching abilities by creating or shifting activities to be more inquiry-based.

A convergent theme between the after teaching reflections, the video reflections, and the after teaching STEBI-B survey indicates that the use of questioning was helpful in guiding and scaffolding learners' inquiry experience. It provides a means for monitoring students' progress and informs the pre-service teacher of the lesson's effectiveness. Data from these three sources also indicate that the pre-service teacher's experience in implementing inquiry-based teaching methods increased her confidence in teaching science.

Comparing the data collected through self-reflections, video reflections, and the PSTE survey prior to and after the teaching experience validates the pre-service teacher's initial inclinations of being able to improve her teaching techniques and shift activities to become more inquiry based. It also validates growth in her science teaching self-efficacy that resulted throughout the planning and implementation phases of this teaching experience.

The findings of this study confirm the literature that suggests action research as a method for teachers to improve their own science teaching (Akerson & McDuffie, 2002; Parsons & Reynolds, 1995; Kang, 1997). Prior to implementation, the pre-service teacher was somewhat confident in her ability to learn new teaching methods. After implementation, her confidence in learning new methods increased, as did her confidence in effectively using these methods in a classroom. Further, this study supports the literature, which suggests that those who have positive experiences will have a more positive self-efficacy (Bleicher & Lindgren, 2005).

In summary, this study has shown that as one develops his or her understanding of inquiry-based science, his or her confidence in planning and teaching inquiry-based science lessons also increases; thus, positive science teaching self-efficacy results. The findings suggest that including inquiry-based teaching early on in teacher education programs and allowing pre-service teachers to practice the methods taught in class before they become teachers helps to develop a strong self-efficacy.

Significance

As inquiry-based science education is becoming increasingly recognized as essential for scientific literacy, it is important for more teachers to be comfortable with this approach. To accomplish this, many teacher education programs stress the importance of inquiry-based science, but few provide opportunities that allow pre-service teachers to engage in inquiry-based practices that are necessary for them to understand its importance at a deep and personal level. The findings from this action research study suggest that providing this opportunity can contribute to both deep understanding of inquiry-based science instruction as well as increased self-efficacy for such teaching.

These findings also suggest an effective method for teacher preparation programs to embrace. More individual pre-service teacher action research studies can provide more perspectives and suggestions for effective teaching strategies. This form of pre-service teacher action research is a form of inquiry in itself and is transferable to virtually any discipline in a teacher education program.

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