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Self-efficacy in Elementary Science: What Impact Do Field Experiences Have on Preservice Teachers

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ABSTRACT

Studies have shown that preservice teachers come to their science methods courses with perceptions about science teaching and learning that can impact their levels of self-efficacy when it comes to teaching science (Bulunuz & Jarrett, 2010; Jarrett, 1999; Kazempour, 2014). Multiple studies have been conducted to document the effects of methods courses on preservice elementary teachers' science self-efficacy, finding the methods course effective in increasing levels of self-efficacy (Flores, 2015; McDonnough & Matkins, 2010; Menon & Azam, 2021) and that these levels of self-efficacy either persist (Wingfield et al., 2000) or decrease due to student teaching (McKinnon & Lamberts, 2014; Settlage et al., 2009). This study sought to examine the relationship between prior experiences, the science methods course, and field experiences for one preservice elementary teacher. Despite having negative experiences with science and an overall sense of overwhelm at the thought of teaching science, Monica displayed high levels of self-efficacy throughout the science methods course and student teaching. By examining STEBI-B surveys, with open questions included, and interview transcripts, this study sought to better understand the interconnectedness of experiences and self-efficacy. Although the results reported here pertain to one preservice elementary teacher, it adds to the overall complex relationship between past, present, and future experiences.

Keywords: self-efficacy; pre-service teachers; field experiences

Introduction

Preservice elementary teachers come to their science methods courses with experiences and thoughts about science that have the potential to influence not only their self-efficacy, but also their desire to teach science content. According to Bandura (1993), low teaching self-efficacy, especially within a certain content area, may lead to avoidance of that subject. Early detection of low self-efficacy in preservice teachers (PSTs) could lead to early interventions and motivate science methods instructors to engage preservice elementary teachers in activities that would increase their self-efficacy in science teaching (Enochs & Riggs, 1990). The science methods course has been shown to increase levels of self-efficacy and that this increase can persist to the end of the student teaching experience (McKinnon & Lamberts, 2014; Palmer, 2006; Palmer et al, 2015; Settlage et al, 2009; Smolleck & Mongan, 2011; Wingfield et al, 2000). What continues to be examined are the experiences that lead to increased self-efficacy, and how PSTs can be encouraged to grow as a classroom teacher.

Theoretical Framework

Social Cognitive Theory

This study is grounded in social cognitive theory. As described by Grusec (1992), Bandura's social cognitive theory recognizes the interaction and influence of three separate factors: 1) individuals, 2) their environment, and 3) their behavior. As individuals engage in their social experiences, they take in information, process it and develop a mental model of their environment. Then, they relate these mental models to outcome expectances (goals of a situation), self-efficacy (perceived abilities), and self-reactions (behavior). In addition to setting goals and selecting a plan of action to produce desired outcomes, peoples' belief in their efficacy (ability to cause a change) determines how long they persist in an environment that presents obstacles to goal achievement. People who believe in their abilities will find ways around obstacles to achieve desired goals. Stated another way, personal self-efficacy beliefs determine a person's motivation, perceived effect of that environment, and courses of action within that environment (Bandura, 1989).

If teachers have low self-efficacy in their teaching abilities, especially within a certain content area, then these teachers may create an environment in which they avoid those particular content areas. On the other hand, teachers with high self-efficacy create environments in which students are engaged in classes and can experience success and/or master their experiences (Bandura, 1993). If teachers demonstrate low self-efficacy in relation to the teaching of science, they will not invest a considerable amount of time in planning for and implementing science instruction. When the focus is on preservice elementary science teachers, it is expected that early detection of low self-efficacy could lead to early interventions and motivate science methods instructors to engage preservice elementary teachers in activities that would increase their self-efficacy in science teaching (Enochs & Riggs, 1990).

In addition to the influence on self-efficacy, social cognitive theory proposes that people learn in two ways: direct experience, either rewarding or not, and social modeling (Bandura, 2003). Essentially, people learn by trying things out for themselves and by observing the actions of others. Through both social modeling and experience, one's self-efficacy is developed. When one overcomes challenges through persistence, and sees others like them being successful, their self-efficacy grows. For preservice teachers (PST), it is their cooperating teaching (CT) in the classroom during field experiences that provides this social modeling and opportunities to take on challenges, through their own teaching and the support they provide the PST.

Literature Review

Science Teaching Self-Efficacy

Multiple studies have measured the science teaching self-efficacy of preservice elementary teachers at various points in their teacher preparation programs. In studies that examined self-efficacy during a science methods course, which also included teaching experiences, increases were found on both subscales of the Science Teaching Efficacy Belief Instrument, Preservice Version ([STEBI-B], Flores, 2015; McDonnough & Matkins, 2010; Menon & Azam, 2021). However, in another study by Cinici (2016), STEBI-B scores increased with a microteaching activity but decreased slightly after the field experience. In addition, Morrell and Carroll (2003) reported increases for the personal science teaching efficacy (PSTE) subscale only after the science methods course and no changes on either subscale during field experiences. From these studies, we see the impact of the science methods course in increasing PSTs self-efficacy beliefs.

Other studies have examined the persistence of these gains in personal science teaching self-efficacy beyond the science methods course. Several studies have reported PSTs increased their levels of self-efficacy from the beginning to the end of the science methods course and that these increases persisted to the end of their teacher preparation program, which included student teaching (Palmer, 2006; Palmer et al, 2015; Smolleck & Mongan, 2011; Utley et al., 2005). Wingfield and colleagues (2000) also reported gains in self-efficacy due to the methods course and that these gains remained the same after one year in the classroom. However, other studies reporting gains in self-efficacy because of the science methods course tend to see decreases in self-efficacy by the end of student teaching, and later when these PSTs start teaching full time in their own classrooms (McKinnon & Lamberts, 2014; Settlage et al., 2009). In another study by Velthuis and others (2014), PSTs were followed throughout their four-year teacher preparation program, finding increases in PSTE from year one to year two, but then a decrease in year three that was maintained in year four. The differing results from these studies indicate there is more to learn about the persistence of self-efficacy beliefs beyond the science methods course.

Prior Experiences

Several studies have examined PSTs prior experiences with science throughout their K-12 school years. In a study conducted by Bulunuz and Jarrett (2010), PSTs who had a higher interest in science also reported more science memories from their elementary school years than those who had a lower interest in science. For those who could remember science from elementary school, their enjoyment of science was reported as above average. Jarrett (1999) found that these positive experiences in elementary science were the greatest indicator of interest in science, followed by high school experiences and informal science experiences. This influence of science experiences was found in another study, yet it was overall experiences which negatively impacted attitude and confidence towards science (Kazempour, 2014). In this study, the PST reported how difficult and challenging her experiences with science were during her K-12 school years. These experiences resulted in her having an extremely negative attitude towards science and very little confidence in her abilities to teach science.

One study examined not just the prior experiences, but also experiences gained during classroom teaching completed during the teacher preparation program and their impact on confidence to teach science (Kazempour, 2013). In this instance, self-efficacy was not only shaped by past experiences with science, but also through experiences gained in the field. For this PST, her past experiences were quite positive, leading to greater interest and confidence in science. It was through her classroom experiences during teacher preparation that further shaped her beliefs about her teaching. Specifically, this PST commented on how she was able to learn more about and implement more effective science instruction by utilizing inquiry-based instruction during her teacher preparation classroom teaching experiences.

Classroom Experiences

Understanding the impact of classroom experiences on one's science teaching self-efficacy is not bound by the experiences PSTs gained from their own K-12 classrooms. Experiences gained in classroom observations and teaching during the teacher preparation program also need to be considered. In a study by Franks et al. (2016), when asked about the most useful aspect of their methods course on impacting their self-efficacy, 98.2% reported the field experience was the most useful. Results from other studies explain that field experiences help PSTs gain more knowledge about the profession, to also help clarify their thoughts and beliefs about inquiry-based science teaching and learning, and influence their levels of self-efficacy, especially when given the opportunity to teach science (Nikoçeviq-Kurti, 2021; Simsar & Jones, 2021; Soprano & Yang, 2013).

During these classroom experiences, it is the cooperating teacher who appears to be the most influential factor. According to Knoblauch and Woolfolk-Hoy (2008), the classroom teacher working with the PST is more influential than the college supervisor responsible for observing/mentoring the PST. Other studies explain that it is the type of relationship the CT and PST have formed that is the basis of this influence. According to Nikoçeviq-Kurti (2021), it is not only that the CTs support the PST, but also that they model how to build relationships with the students and tailor the teaching to meet student needs. It is this modeling behavior that has shown a direct impact on PSTs' levels of self-efficacy. Simsar and Jones (2021) found that the behaviors modeled by the CTs and the feedback they provided were crucial in the development of self-efficacy in PSTs.

Purpose and Research Questions

It was the aim of this study to examine the relationship between prior experiences with science, the science methods course, and classroom teaching experiences on the levels of science teaching self-efficacy and perceptions of science teaching for preservice elementary teachers. The overarching research question guiding this study was: How do prior experiences with science and classroom teaching experiences, in addition to the science methods course, affect the level of science teaching self-efficacy and the perceptions of science teaching for preservice elementary teachers? The specific research questions were:

1) What are the personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE) beliefs of preservice elementary teachers as measured by the STEBI-B at the beginning and end of their science methods course, and the end of the student teaching semester?
2) What is the impact of prior experiences on self-efficacy and the perceptions of science teaching?
3) What is the impact of the science methods course on self-efficacy and the perceptions of science teaching?
4) What is the impact of classroom teaching experiences during student teaching on self-efficacy and the perceptions of science teaching?

Methods

This study utilized a convergent parallel mixed methods case study design to better understand the relationship between classroom teaching experiences and the level of science teaching self-efficacy for one preservice elementary teacher. A convergent parallel mixed methods case study design was selected because it would allow a more in-depth examination of the intersection between classroom experiences (both prior and current), the science methods course, and science teaching self-efficacy through the collection of different, yet complementary data sources (Creswell, 2009; Creswell & Plano-Clark, 2011). As a part of this approach, several pieces of both quantitative and qualitative data were collected to develop and understand this one PST's relationship with science and her beliefs in her abilities to teach the subject.

For the quantitative data, this PST completed the STEBI-B (Enochs & Riggs, 1990) at three different points: the beginning of the science methods course, the end of the science methods course, and again at the end of the student teaching semester (which immediately followed the science methods course). For the qualitative data, open questions were answered at the end of the STEBI-B. These questions asked about past and current experiences with science, descriptions of good versus bad days in science, descriptions of good versus bad science teachers, and how this PST envisioned science instruction for her future classroom. Additionally, this PST completed two individual interviews: one at the end of the science methods course and the other at the end of student teaching. These interviews asked the preservice elementary teacher to describe their classroom teaching experiences at both of their placements, during the science methods course and student teaching semester. As a part of the teacher preparation program, PSTs have two field placements during their program which they split their time attending. These placements are designed to provide a variety of experiences both in grade level and content area.

Participant and Course Context

The participant for this case study was selected because of her varied experiences both prior to the methods course and during her student teaching semester. Monica (a pseudonym) identified herself as a white female and was in her last year of the elementary teacher preparation program at a large urban university in the south.

The teacher preparation program for the elementary grades provides a pathway to certification for grades Pre-kindergarten to sixth grade in all four core content areas: English Language Arts/Reading, Mathematics, Science, and Social Studies. As a part of this program, PSTs are assigned two different field placements during their program; one placement in the lower grade band of pre-K to third grade and the other in the upper grade band of third to sixth grade; ideally, PSTs should have a variety of content areas between the two placements, sometimes in a self-contained classroom teaching all subjects to a single or double subject classroom (i.e., mathematics only or a combination of mathematics and science).

The science methods course was taken the semester prior to student teaching. During the 16-week semester, PSTs are also completing their one-day-a-week field experience where they attend their placements one day each week during the semester (eight weeks at their first placement and eight weeks at their second placement). The science methods course was taught through a hands-on approach where students completed science activities as if they were the students themselves and then analyzed the implementation of the activities from the teacher's perspective. Due to the virtual nature of the course, students completed science activities at home with everyday materials, then the activities were discussed during the virtual synchronous class meeting.

Student teaching is the final semester of the teacher preparation program and immediately follows the semester in which PSTs complete the science methods course. Also 16 weeks in length, PSTs attend their placements all day, Monday-Friday. As with the prior semester, the PSTs split their time between placements, with eight weeks at each placement. Placements during the student teaching semester are the same two placements from the previous semester. In addition to attending their placements, the PSTs attended monthly program seminars, where they reviewed additional topics relevant to their current teaching (i.e., classroom management, job searches, etc.).

Data Collection

STEBI-B

The STEBI-B (Enochs & Riggs, 1990) measures the levels of PSTs self-efficacy towards their ability to teach science. This survey consists of 23 items, all requiring PSTs to respond to 5-point Likert-type statements. The STEBI-B is divided into two subscales: personal science teaching efficacy (PSTE) and student outcome expectancy (STOE). The STEBI-B was administered at three different points: the beginning of the science methods course, the end of the science methods course, and at the end of student teaching. At the conclusion of the STEBI-B were open questions that allowed PSTs to describe their past and current experiences with science, good versus bad days in science, good versus bad science teachers, and how science would be taught in their future classroom.

Interviews

Individual interviews were completed at the end of the science methods course and then again at the end of the student teaching semester. Both interviews were conducted virtually through Microsoft Teams and lasted about 30 minutes. Both interviews were recorded. The purpose of the first interview was to gain insight into experiences during the science methods semester, including the teaching of the science lesson plan. In addition, questions were asked about confidence to teach science both before and after the science methods course. Example prompts included: Describe your two placements and the science instruction you saw in each. Describe the science lesson plan you wrote for the methods course and what it was like to teach it. If you could teach your science lesson plan again, what (if anything) would you do differently and why? What was your confidence to teach science before the course? What is your confidence to teach science now, after the course? The purpose of the second interview was to gain insight to the student teaching semester and its potential influence on confidence to teach science. Example prompts included: Briefly describe your student teaching experience for each placement. How successful do you feel in your science teaching? What are those feelings based upon? Has anything increased your confidence to teach science? Has anything decreased your confidence to teach science?

Data Analysis

Overall Analysis

Following the recommendations outlined by Creswell and Plano-Clark (2011), quantitative and qualitative data were collected at the same points and treated equally, owing to the value each piece provided in the overall interpretation. Each piece of data was analyzed separately and then combined to complete an overall interpretation. Specifically, the data was analyzed to determine if, and in what ways, the two sets of results converged, diverged, related, and/or combined to form a better overall understanding of this PST's experiences and self-efficacy towards science teaching. In addition, the use of a single case study will provide a deeper analysis for this PST (Rowley, 2002).

STEBI-B Analysis

Participant responses were entered into Excel using the original protocol from Enochs and Riggs (1990). Ten of the 23 statements were worded negatively and thus were reverse scored to maintain consistency between the positively and negatively worded statements. Responses were totaled for each subscale for each of the survey collection points (pre, post, and delayed post). Total scores for each subscale and each collection point were analyzed and compared for changes.

Open Questions

Responses to the open questions were compiled into a table and organized by question and iteration of survey (i.e., pre-methods course, post-methods course, and post-clinical teaching). Responses were then examined for any changes between the different iterations. Table 1 provides a sample of the questions and Monica's responses.

Interview Analysis

Overall steps followed the procedure outlined by Saldana (2015), which were to: 1) read through the two interviews (post-methods course and post-student teaching) for initial codes; 2) read through the two interviews again to verify and clean the initial codes; 3) develop categories from the codes; and 4) compare categories to literature and the theoretical framework. Initial categories were based on the questions from the structure of the interviews, but then open codes were developed based on the responses, as described by Elliot (2018). To ensure validity, the researcher coded a clean version of the document to ensure coding was consistent (Elliot, 2018). Table 2 displays the categories, codes, and example texts from interviews.

Table 1

Sample of the Open Questions and Participant Responses

Prompt	Pre-Methods Course	Post-Methods Course	Post-Clinical Teaching
What three words or phrases would you use to describe a "good day" in science?	Engaging Imaginative Flexible	Fun Hands-on Direct	Engaged Creative Communicating
If you are planning on teaching science in the future, what will science instruction look like in your future classroom? If you are NOT planning on teaching science in the future, how could you incorporate science concepts into your classroom instruction in the future?	I plan to use science as a way to discover all types of things that can apply to other subjects or are practical to know and use in daily life. I want to use science as a tool to understand things and ask questions that open students' minds and perspectives on the world.	I plan to have lots of experiments, games, and puzzles	Science instruction will be very engaging, with hands on activities and experiments for students to explore. Lots of time for asking and discussing questions, terms, and ideas.

Table 2

Categories, Codes, and Example Text from Interviews

Categories (based on interview structure)	Initial Codes (based on responses)	Example Text (Interview) 1 – post science methods 2 – post clinical teaching
Science Instruction Modeled in Each Placement	Instruction	It [science] was taught on its own (kindergarten placement; Interview 1) would start up with a video [science with CT1] (Interview 2)
	Integration	connecting the that to like the word of the day or the question of the day (kindergarten placement; Interview 1) would try and tie in the science with other subjects too (Interview 2)
	Assessment	answer through examples (Interview 1) then they would answer some questions [science with CT1] (Interview 2)
	Collaboration	discuss it together (Interview 1)
	Routine	that's not the norm (placement instruction; Interview 1)

Categories (based on interview structure)	Initial Codes (based on responses)	Example Text (Interview) 1 – post science methods 2 – post clinical teaching
	Pandemic	you know circumstance that we're in (Interview 1) normally with like without COVID they would go outside and do like a rock hunt [science with CT1], but they weren't really allowed to go outside 'cause they would kind of be close to each other (Interview 2)
	Mentor	I learned from them [CT] (Interview 1) she [CT2] was like I'm here any questions, anything you, you need, like let me know (Interview 2)
	Monitoring	[CTs] observed very closely (Interview 1)
	Giving Up	And they're [CTs] like, "OK, well, I'm not even going to do anything today because they're going to get mad at me no matter what." (Interview 1)
	Planning	she [CT1] didn't want me to make new lessons. She didn't want me to come up with new ideas (Interview 2)
Confidence to Teach Science	Confidence	I was like if I don't, even if I wasn't even taught what these kids are going to be taught, how can I teach it? (Interview 1) But I remember being like oh yeah, I'm not going to be good at teaching science like kind of being scared about the thought of doing that. And then now I'm like, oh yeah, I can definitely teach science. Like I loved teaching science. (Interview 2)
	Knowledge	thinking like, "OK, well I have to be this super smart I need to know everything and just tell them and like know how to explain it well" (Interview 1) I want to make sure that they're not questioning my content knowledge (Interview 2)
	Overwhelm	I remember being overwhelmed by science (Interview 1)
Factors Affecting Confidence	Enjoyment	it was fun (teaching the lesson plan from methods course) (Interview 1)
	Impact	I think the course definitely did like facilitate that realization for me (ability to teach science) (Interview 1) I notice that the things that we reviewed that I taught them they knew still and the things that we reviewed that they, I didn't teach them they didn't know at all [science]; the hands-on stuff really made a difference (Interview 2)
	Ability	that really seems like scared me because I could not do the chemistry. I could not do physics (Interview 1)
Experiences with Teaching Science	Challenges	it was hard to narrow down what exactly I wanted to incorporate (Interview 1) you can't give in person kids different assignments than the online kids [due to pandemic]; that was I think the biggest challenge (Interview 2)
	Activity(ies)	they can learn through doing (Interview 1) I tried to have them do a lot of hands on stuff and she [CT2] did too (Interview 2)
	Choice	if I don't like this activity or if it doesn't really fit with my assessment questions, I can change it to another one (Interview 1) she [CT2] was like, you know, anything you want to do, you can do (Interview 2)
	Application	on paper it was a lot more, you know, hands on, than the actual lesson (Interview 1)
	Multiple Days	I would want to spend more than just one class (Interview 1)

Categories (based on interview structure)	**Initial Codes (based on responses)**	**Example Text (Interview)** **1 – post science methods** **2 – post clinical teaching**
	Scaffolding	it's really good when science lessons are built on each other (Interview 1)
	Rigid/Flexible	have to use this book and only this set of standards and only these topics (Interview 1) I had to adapt it [instruction/activities] a lot (Interview 2)
	Responsibility	she [CT2] let me take more control with that; I liked it a lot (Interview 2)
	Enjoyment	I was having a really great time with them [5th graders] and they were really excited to do the science (Interview 2)
	Technology	I used a lot of like online tools (Interview 2)
	Engagement	they could do more of this stuff as a class and so the online kids would be engaged in the same way that the in person kids were [using online tools] (Interview 2)
Experiences with Science in General	Experiences	I think like it [confidence in science] goes back to my own experience in school like my science, I never had like that hands on kind of experience. Like it was mostly just lecture and then textbook questions. (Interview 1) So she [CT2] kind of pushed me off the diving board in a way and I was scared. But I felt so grateful for that experience because at the end of it I was like oh, I'm totally ready to do this 'cause I've been doing it this whole time (Interview 2)

Findings

Early Experiences

Monica attended a small, faith-based school for all her K-12 school years. Science in this school was aligned to a very narrow curriculum that fit within the bounds of the religious beliefs of the school. She remembers completing science experiments, which she found to be fun and enjoyable, however she also realized these experiments were not the norm. When asked to describe a positive experience, Monica described a time in fourth grade when her class conducted an experiment where they observed the growth of mold on bread after being rubbed on a variety of surfaces. On the other hand, when asked to describe a negative experience, Monica mentioned a specific teacher in eighth grade who tried to trick students on tests by giving questions that could have multiple answers or on topics not yet covered.

Looking back on her past experiences, Monica came to the realization that she would have to "do basic science research" (Interview 1) to become more familiar with topics she would have to teach in the future. This led to feelings of overwhelm and that she "would have to be this super smart science person" (Interview 1) to be able to teach science to her future students. Essentially, Monica came to her science methods course feeling that if she "wasn't even taught what these kids are going to be taught, how can I teach it" (Interview 1)?

Experiences in the Methods Course

Self-efficacy at the Beginning of the Science Methods Course

Based on the STEBI-B taken at the start of the science methods course, Monica held moderately high levels of PSTE, with a score of 53/65 on this subscale. Specifically, Monica strongly agreed with the statement "I will continually find better ways to teach science." Whereas she agreed with the statement "I wonder if I will have the necessary skills to teach science." As for the STOE subscale, Monica held a moderate level, scoring 33/50 on this subscale. She agreed with the statement "The teacher is generally responsible for the achievement of students in science" and was neutral to the statement "Students' achievement in science is directly related to their teacher's effectiveness in science teaching." When asked to describe her level of confidence to teach science, Monica stated that it was neutral to negative and that she felt "overwhelmed by science."

Thoughts about Science Teaching at the Beginning of the Science Methods Course

When asked to share her thoughts about a good day in science, Monica stated it would be engaging, imaginative, and flexible, whereas a bad day in science was described as restrictive, overwhelming, and confusing. Monica described a good science teacher as creative, communicative, and open-minded, but a bad science teacher as boring, unclear, and rude when students do not understand the content. Monica believed that her ability to be an effective elementary science teacher was "above average." When asked to describe how science should be taught, Monica said it should be more activity-based instruction than a textbook-based presentation. Specifically, Monica stated:
"I plan to use science as a way to discover all types of things that can apply to other subjects or are practical to know and use in daily life. I want to use science as a tool to understand things and ask questions that open students' minds and perspectives on the world" (pre-course survey).

Early Field Experiences During the Science Methods Course

During the semester Monica took the science methods course, she also had early field experiences in two different classrooms. As part of these experiences, she spent one day each week in the classroom, eight weeks in Placement one, and eight weeks in Placement two for a total of 16 weeks. For Monica's first placement, she visited a kindergarten classroom where all subjects were taught by her CT, and more than half of the instruction was face-to-face. When asked about the format of science instruction, Monica explained that science was taught on its own, but was connected to a word or question of the day. Additionally, science instruction involved mostly the showing of videos and then completing worksheets and took up approximately 150 instructional minutes per week. For her second placement, Monica visited a fifth-grade mathematics and science classroom, where her CT taught both subjects and more than half of instruction was face-to-face. Science was taught on its own and involved the use of videos and online questions, taking up approximately 100 instructional minutes per week.

Self-efficacy and Beliefs About Teaching at the End of the Science Methods Course

At the end of the course, Monica again took the STEBI-B, indicating very little change on the PSTE subscale, scoring 55/65 (+2 versus the pre-test). These small changes can be seen in her responses to the statement "Even if I try very hard, I will not teach science as well as I will most subjects," moving from disagree to strongly disagree, and to the statement "I know the steps necessary to teach science concepts effectively," moving from agree to strongly agree. On the other hand, Monica's scores on the STOE subscale increased from 33 to 41/50 (+8 versus the pre-test). These changes can be seen in her responses to the statement "When a student does better than usual in science, it is often because the teacher exerted a little extra effort," moving from disagree to agree, and to the statement "When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher," moving from neutral to agree.

When asked to describe her level of confidence to teach science, Monica stated that it was definitely positive, explaining that "I know more than I thought I did" (Interview 1). Monica shared that, through the methods course, she learned she can use experiments and activities to assist in her teaching, that students can learn through doing, and that the course helped her to learn that there are different ways to teach science than how she learned in her K-12 school years. Monica also explained that seeing her CTs teach science (and having fun with it) helped increase her own level of confidence to teach science.

Thoughts about Science Teaching at the End of the Science Methods Course

Again, Monica was asked to describe a good day in science and a bad day in science. For her, a good day is "fun, hands-on, and direct," whereas a bad day is "confusing, disinterested, and includes worksheets." Likewise, Monica was asked to describe the characteristics of a good science teacher and a bad science teacher. She described a good science teacher as "creative, expressive, and encouraging," and a bad science teacher as "unenthusiastic, disengaged, and boring." As in the pre-course survey, Monica stated that her effectiveness as a future elementary science teacher would be "above average." Again, Monica stated that science instruction should be more activity-based than a textbook-based presentation. As for her future classroom, she plans to have lots of experiments, games, and puzzles.

Experiences in Student Teaching

Immediately following the science methods course, Monica had her student teaching semester. During this semester, she visited the same two classrooms from her early field experiences, this time spending all day Monday to Friday in each placement, again eight weeks in Placement one (kindergarten, all subjects) and eight weeks in Placement two (fifth-grade mathematics and science). In Monica's first placement, science instruction began to be incorporated with other content occasionally, taking approximately 100 instructional minutes each week. There were more hands-on activities, in addition to the videos, and use of the interactive web platform SeeSaw. When describing her experiences from her first placement, Monica explained that her CT developed the science lessons for the grade level team and that her experience teaching was "a little more restrictive" (Interview 2). When asked to explain further, Monica said they were not able to do much because of the pandemic, with half of the students online and the other half in person. She stated the overall experience was tough, but that it was also good to get that experience.

During the student teaching semester in her second placement, Monica noted that science was once again taught on its own, taking approximately 150 instructional minutes per week. There were some hands-on activities, in addition to the videos, and copying terms into a notebook. When describing her experiences from her second placement, Monica explained that another teacher on the grade level team developed the science lessons, but that she and her CT modified them. Monica stated that her CT in this placement encouraged her to try anything she wanted, explaining that the students' lowest benchmark scores were in science, so the CT wanted to engage them more. Overall, Monica liked having more responsibility and control, stating that her second CT "pushed me off the diving board in a way" (Interview 2). Monica also indicated that she felt more comfortable teaching to this age group of students.

Self-efficacy at the End of Student Teaching

At the conclusion of her student teaching semester, Monica completed the STEBI-B for a third time. Table 3 provides her scores for all three iterations of the STEBI-B.

Table 3

Monica's STEBI-B Results

STEBI-B Subscale (Highest Possible Score)	Pre-test	Post-test	Change (Pre to Post)	Delayed Post-test	Change (Post to Delayed Post)
PSTE (65)	53	55	+2	64	+9
STOE (50)	33	41	+8	43	+2

For her PSTE, Monica held moderately high levels at the start of the science methods course, with very little increase at the end of the science methods course, and then a large increase at the end of student teaching. The statement on the PSTE subscale that showed the largest change was "I wonder if I will have the necessary skills to teach science," moving from agree to disagree. Most of the other statements in this subscale moved from agree to strongly agree.

As for her science teaching outcome expectancy, Monica held a moderate level at the start of the science methods course, with a large increase at the end of the science methods course and then very little increase at the end of student teaching. The statement on the STOE subscale that showed the largest change was "When a student does better than usual in science, it is often because the teacher exerted a little extra effort," moving from disagree (pre-test) to agree (post-test) to strongly agree (delayed post-test). Other statements moved from neutral to agree (e.g., "When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher") or from disagree to neutral ("If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher").

Beliefs about Teaching Science at the End of Student Teaching

Table 4 includes the phrases Monica used to describe good and bad days in science, as well as good and bad science teachers at all three data collection points.

Table 4

Descriptions of Classroom and Teacher Characteristics

Category	Pre-test Phrases	Post-test Phrases	Delayed Post-test Phrases
Good Days	Engaging Imaginative Flexible	Fun Hands-on Direct	Engaged Creative Communicating
Bad Days	Restrictive Overwhelming Confusing	Confusing Disinterested Worksheet	Confusing Boring Anxious
Good Science Teacher	Creative Communicative Open-minded	Creative Expressive Encouraging	Flexible Knowledgeable Fun
Bad Science Teacher	Boring Unclear Rude when students do not understand	Unenthusiastic Disengaged Boring	Bad communicator/unclear Closed off Difficult

When examining the words Monica chose to describe a good day in science, the phrase “engaging/engaged” appears at two different points, indicating Monica’s belief that the central feature of a good day in science is when students are a part of the learning process. On the other hand, when it comes to a bad day in science, Monica was consistent in the use of the phrase “confusing,” indicating a belief in that when students do not understand the material, this leads to a bad day in science. When describing the characteristics of a good science teacher, Monica used the phrase “creative” at two different points and then “flexible” on the third iteration. For Monica, being a good science teacher involves imagination on the part of the teacher and not being fully bound to one idea. When describing the characteristics of a bad science teacher, Monica used the phrase “boring” at two different points, indicating that bad science teachers are either not engaged with students or materials or excited to be teaching.

When asked to describe how science should be taught, once again Monica felt science instruction should be more activity-based instruction than textbook-based presentation. As for science in her future classroom, it will be very engaging, with hands on activities and experiments for students to explore and lots of time for asking and discussing questions, terms, and ideas. Maintaining a consistent belief in her effectiveness as a future elementary science teacher, Monica stated she would be “above average” yet again. When it came to describing her overall beliefs in her ability to teach science and how they changed from the start of the science methods course to end of student teaching, Monica explicitly stated:

> I remember being like oh yeah, I'm not going to be good at teaching science like kind of being scared about the thought of doing that. And then now I'm like, oh yeah, I can definitely teach science. Like I loved teaching science!

Discussion

The overarching research question guiding this study was: How do prior experiences with science and classroom teaching experiences, in addition to the science methods course, affect the level of science teaching self-efficacy and the perceptions of science teaching for preservice elementary teachers? The specific research questions were:

1) What are the PSTE and STOE beliefs of preservice elementary teachers as measured by the STEBI-B at the beginning and end of their science methods course, and the end of the student teaching semester?
2) What is the impact of prior experiences on self-efficacy and the perceptions of science teaching?
3) What is the impact of the science methods course on self-efficacy and the perceptions of science teaching?
4) What is the impact of classroom teaching experiences during student teaching on self-efficacy and the perceptions of science teaching?

Research Question 1: Changes in Self-efficacy

As shown previously in Table 1, Monica’s scores on both subscales of the STEBI-B increased from the beginning of the science methods course semester to the end of the clinical teaching semester. From the beginning to the end of the science methods course, Monica’s scores on the STOE subscale showed a greater increase than on the PSTE subscale, indicating the methods course had a greater impact on her beliefs in her ability to affect student outcomes. The increases on the STEBI-B during the science methods course support the findings reported in previous studies (Flores, 2015;

McDonnough & Matkins, 2010; Menon & Azam, 2021). From the end of the science methods course to the end of clinical teaching, Monica's overall STEBI-B increased, yet this time it was the PSTE subscale that showed the greater increase. This continued increase in scores on the STEBI-B during student teaching support the results from other studies (Palmer, 2006; Palmer et al, 2015; Smolleck & Mongan, 2011; Utley et al., 2005). For Monica, the greatest increase for the PSTE subscale occurred from the end of the science methods course semester to the end of the student teaching semester. On the other hand, the greatest increase for the STOE subscale occurred from the beginning to the end of the science methods course semester. These results indicate that, for Monica, the methods course had a greater impact on her beliefs in her ability to affect student outcomes, whereas the student teaching semester had a greater impact on her beliefs in her ability to teach science, supporting the findings from several other studies.

Research Question 2: Impact of Prior Experiences

Monica stated that she felt unprepared and overwhelmed when it came to teaching science, mostly due to her own K-12 science experiences. According to Monica, the science taught in her small school was very limited and she knew she would have to learn more science content to be able to teach it effectively to her future students. Like the findings presented by Kazempour (2014), experiences with science in K-12 classrooms can directly impact confidence in science. However, Monica's acknowledgement that she would need to further her study of science topics seems to contradict the findings reported by Jarrett (1999) in that negative, or limited, experiences do not necessarily turn someone away from science. For Monica, she was aware of her limited science content and recognized the need for continued study if she were to be able to teach science to her future students. This realization may explain Monica's moderately high scores on the initial STEBI-B.

Research Question 3: Impact of the Science Methods Course

As illustrated in the larger increase on the STOE subscale, the science methods course had a greater impact on Monica's beliefs in her ability to affect student outcomes. These findings contradict those by Morrell and Carroll (2003). By modeling the implementation of science activities into the elementary classroom, Monica stated that the science methods course showed her the steps necessary for engaging students in the learning process. By encouraging students to learn by doing, Monica realized that instruction was not fully dependent on her content knowledge and being solely responsible for passing on that knowledge, but rather that students would gain understanding through activities.

Research Question 4: Impact of Classroom Teaching Experiences

Monica experienced more flexibility and freedom in her teaching during her second placement, a fifth-grade mathematics and science class. She explained that her CT in this particular classroom modified the grade-level developed lesson plans and encouraged her to try different activities or methods of instruction. Overall, her CT gave Monica more responsibilities than her previous CT. Monica noted that students seemed to comprehend the concepts more and show more excitement when hands-on activities were implemented. Monica felt it was this level of responsibility that directly impacted her confidence to teach science. Monica's explanation of how her teaching impacted her confidence to teach science mirror the findings from several studies (Nikoçeviq-Kurti, 2021; Simsar & Jones, 2021; Soprano & Yang, 2013), indicating that the actual act of teaching is what impacts self-efficacy the most. It appears that for Monica, it was the mentorship and modeling of the CT that were at the center of further developing self-efficacy during the student teaching semester, as noted in prior research (Knoblauch & Woolfolk-Hoy, 2008; Simsar & Jones, 2021).

Implications

Although the findings presented here are limited to only one PST and her perceptions about science teaching, much can be learned from her experiences. The science methods courses within teacher preparation programs lay the foundation for science instruction in the elementary classroom. Modeling science activities, especially those that allow students to gain understanding for themselves, is crucial for three reasons. One, these activities allow PSTs to see first-hand what is needed to implement a science activity, both from the student perspective and the teacher perspective, leading to increased levels of science teaching self-efficacy. Second, when PSTs experience the science activities for themselves, they are able to connect these activities to their future teaching and how they provide meaningful learning experiences for their future students. Third, these activities provide an opportunity to address preservice elementary teacher understanding of science concepts common to the elementary curriculum. This will lead PSTs to understand the level of science understanding they need to possess themselves, and also how to help their future students increase their own level of understanding in science.

Building from teacher preparation courses, the student teaching experience provides opportunities for PSTs to practice the implementation of science activities when they are supported by their CTs. It is vital for CTs to encourage and support these PSTs as they are practicing. First, CTs need to be willing to allow the PSTs opportunities to take on more responsibilities gradually throughout their time in the clinical teaching experience. The CT should be there to gently push PSTs, but also model interactions with students, fellow teachers, administrators, and parents. Second, CTs can provide some flexibility to the preservice elementary teachers to implement the strategies learned from the courses within their teacher preparation program, as they gradually take on more responsibility.

This second point requires collaboration between multiple stakeholders: the teacher preparation program, the school administration, and the classroom teacher. Teacher preparation programs should be in constant communication with school administration so both parties are aware of best practices, the teacher preparation program providing the research aspect and the school administration providing the field-based aspect. Teacher preparation programs need to be aware of the most current classroom situations teachers are facing so they can ensure the courses reflect those occurrences and teach to those practices. School administration needs to be aware of current research trends and how those might affect classroom practice. Finally, CTs need to be given flexibility in creating supportive environments for preservice teachers, encouraging them to practice strategies reflective of the most current research and needs of the students and schools.

Conclusions

Many factors affect the development of science teaching self-efficacy: prior experiences, the science methods course, and classroom teaching experiences. This is a very complex relationship that is not a *one-size-fits-all* situation. Some PSTs who have limited or negative experiences with science will either avoid science and develop low science teaching self-efficacy, while others with those same limited or negative experiences will use them as a launchpad to learn more about science and how best to teach it. Regardless of the type of prior experiences PSTs have with science, they must come to acknowledge them and how they might affect their abilities to teach science and then proactively participate in science methods courses that are designed to model the most current research and best practices for the elementary science classroom. Then, when these PSTs go into their student teaching experiences, they need to be supported by their CTs and schools to try out these practices. The preparation of the next generation of teachers requires the collaboration of classroom teachers, their school administration, and the teacher preparation program. Further research should examine how early years of teaching continue to shape science teaching self-efficacy. This could lead to the development of support systems for recent graduates and other in-service teachers.

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