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Abstract

Self-efficacy beliefs play a major role in determining teachers' science teaching practices and have been a topic of great interest in the area of preservice science teacher education. This qualitative study investigated factors that influenced preservice elementary teachers' science teaching self-efficacy beliefs in a physical science content course. The primary data sources included Science Teaching Efficacy Belief Instrument-B (STEBI-B) responses, two semi-structured interviews, classroom observations, and artifacts. Analysis of STEBI-B data was used to select 18 participants with varying levels of self-efficacy beliefs: low, medium, and high. Four categories representing course-related factors contributing towards participants' science teaching self-efficacy beliefs were found: (1) enhanced science conceptual understandings, (2) active learning experiences, (3) teaching strategies, and (4) instructor as a role model. While some course elements such as hands-on learning experiences and in-

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quiry-based teaching strategies seemed to impact all groups positively, the low-group participants were particularly benefited from the ways in which science concepts were presented and the pace at which learning progressed. One implication from this study is that science educators could include elements within science content courses to potentially support preservice teachers with varied initial levels of science teaching self-efficacy.

Keywords: elementary science, preservice teacher education, science content courses, science teaching self-efficacy, sources of self-efficacy

The science education community continues to face challenges regarding effective science instruction at the elementary level (Appleton & Kindt, 1999; Avery & Meyer, 2012). In a recent national survey conducted in the USA, 67% of elementary teachers reported feeling unprepared to teach *any* science, and only 17% felt prepared to teach physical science (Banilower, Smith, Weiss, Malzahn, Campbell, & Weiss, 2013). Research suggests that physical science is taught less than other science disciplines (Atwater, Gardner, & Kight, 1991; McDermott, 1990) and reforms efforts consistently called for higher-quality science teaching in elementary classrooms (American Association for the Advancement of Science, 1993; NGSS Lead States, 2013; National Research Council [NRC], 1996; NRC, 2012). Despite these calls, questions have been raised regarding elementary teachers' limited science content training and its negative impact on science teaching attitudes and beliefs (Knaggs & Sondergeld, 2015; Rice & Roychoudhury, 2003).

Research has shown that teachers' negative beliefs, based on poor science experiences, may impact instructional practices (Avery & Meyer, 2012; Bautista, 2011; Kazempour & Sadler, 2015). Most preservice science content courses consist of lecture, reading, and worksheets that promote rote memorization (Mulholland & Wallace, 1996; Rice & Roychoudhury, 2003) and lead to poor science knowledge (Trundle, Atwood & Christopher, 2002). These negative experiences adversely affect preservice elementary teachers' confidence and can push them to avoid teaching science altogether (Jarrett, 1999; Mulholand & Wallace, 2001). Experiences during coursework have been linked to teachers' beliefs that serve as a lens for classroom decision-making (Bandura, 1986, 1997). As a result, the interrelationship between teachers' beliefs, attitudes, and classroom behaviors (Bandura, 1977, 1982, 1997) has been a topic of interest for science teacher education.

Over the past three decades, Bandura's construct of self-efficacy beliefs has been empirically linked to teacher behavior and instructional practices (Bandura, 1997). Early conceptualizations of self-efficacy positioned the construct as beliefs that influence one's thought processes and guide subsequent actions in pursuit of a desired goal (Bandura, 1986). The fact that self-efficacy is important for future science teaching has been established (Cantrell, Young &Moore, 2003; Palmer, 2006a), but it is well documented that elementary teachers do not have the levels of self-efficacy needed to support high-quality teaching and learning (Knaggs & Sondergeld, 2015; Rice & Roychoudhury, 2003). Past studies have emphasized that understanding preservice teachers' initial levels of science teaching self-efficacy would help course instructors to tailor science instruction to meet their specific needs within preservice coursework (Kazempour & Sadler, 2015; Swackhame, Koellner, Basile, & Kimbrough, 2009). However, additional research is needed, especially in the context of science content courses, to address *how* preservice teachers with varied initial levels of science teaching self-efficacy are supported within science content courses to achieve the levels of self-efficacy needed for successful science teaching.

The present study not only adds to the existing literature on understanding how science teaching self-efficacy beliefs are shaped within science content courses but also addresses the gap in the literature on how to attend to and support a diverse mix of preservice teachers. Thus, the study was motivated by the conjecture that preservice elementary science teachers with different levels of self-efficacy beliefs may attend to different course aspects during their participation in science content courses, and these differences may affect their perceptions of science and science teaching. Therefore, questions about how self-efficacy may be developed in science *content* courses, as well as what and how course factors may support increasing self-efficacy beliefs, warrant attention. This study investigates the *course-related factors* that support preservice elementary teachers with different initial levels of science teaching self-efficacy beliefs.

Studies have consistently shown that science method courses can support development of self-efficacy beliefs, but science method courses are only a part of teacher training. Researchers have also found that preservice teachers often arrive in science method courses with biases and concerns about their preparedness for science teaching (Rice & Roychoudhury, 2003; Yoon, Pedretti, Pedretti, Hewitt, Perris, & Van Oostveen, 2006). However, little research has been conducted to understand what those pressing concerns are and how they impact self-efficacy beliefs, especially after preservice teachers complete their science content courses that often precede their science method coursework. Failure to cope with such persistent concerns may have long-lasting effects on preservice teachers' science teaching self-efficacy beliefs and consequently interfere with future science instructional practices. This present study addresses this gap by investigating preservice teachers' concerns regarding science and science teaching after their participation in the science content course.

Focus of This Research and Research Questions

This study is a part of a longitudinal exploration of changes in preservice elementary teachers' science teaching self-efficacy beliefs, science conceptual understandings, and relationships between the two constructs in a science content course. In earlier work associated with this study (Menon & Sadler, 2016a; 2016b), we documented significant positive changes in preservice elementary teachers' ($N = 51$) personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE) as well as science content knowledge (see **Table 1**). We administered Science Teaching Efficacy Belief Instrument-B (STEBI-B) (Bleicher, 2004) as pre- and post-tests. The STEBI-B instrument consists of a total 23 items with a five-point Likert scale. The PSTE scale consists of 13 items with scores that can range from 13 to 65, and the STOE scale consists of 10 items with scores that can range from 10 to 50.

In addition to participants' improved self-efficacy on both scales, we found a significant correlation between the gains in PSTE (belief in one's self to perform a task—science teaching in this case) and gains in science content knowledge ($r = 0.35$, $p \ll .05$). However, there was no significant correlation between gains in STOE (beliefs about student outcomes as a result of science teaching) and gains in science content knowledge. The correlation ($r = 0.35$) is moderate but significant; the relationship explains a limited amount of the underlying variability. Recognizing that science teaching self-efficacy beliefs are complex and malleable, there are likely other mediating factors/variables involved in the development

Table 1 Descriptive Statistics and Univariate Tests (*N* = 51)

Measure	*Pre mean, SD*	*Post mean, SD*	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
PSTE	44.76, 6.19	51.80, 6.03	1263.539	1	1263.539	95.295*	0.000
STOE	34.67, 3.66	36.78,3.81	114.353	1	114.353	10.795*	0.002
Content	5.98, 2.44	9.19,2.74	263.686	1	263.686	71.146*	0.000

* $\alpha = .05$.
Maximum possible scores: PSTE = 65, STOE = 50, and Content = 15.
Adapted from Menon & Sadler (2016a).

of science teaching self-efficacy beliefs and science content knowledge (Menon & Sadler, 2016a; 2016b).

Given these findings, we were interested in how, what, and the conditions under which participants' science teaching self-efficacy improved during their participation in the course. The study was guided by two overarching research questions:

1. What factors associated with a specialized physics content course contribute to preservice elementary teachers' science teaching self-efficacy (PSTE and STOE) beliefs?
2. What are preservice elementary teachers' concerns regarding science teaching following their participation in a specialized physics content course?

Review of Theoretical and Empirical Literature

Self-Efficacy

This study is grounded in self-efficacy beliefs—an aspect of Bandura's social cognitive theory. Social cognitive theory postulates that human functioning is determined by the interaction of three factors: (1) personal factors such as beliefs, (2) behavior, and (3) environmental influences (Bandura, 1986). The theory offers a blend of behavioristic and cognitive theories of learning, which emphasize learning as a product of the interplay between cognitive, behavioral, and contextual factors. Bandura proposed a model of the three interrelated factors, "triadic reciprocal causation," to influence human behavior. Derived from social cognitive theory, self-efficacy has emerged as an influential construct, suggesting that beliefs have a tendency to change while individuals interact with the environment in which they function (Bandura, 1982). Bandura further proposed two dimensions of self-efficacy: (1) personal efficacy as the beliefs in one's capabilities to achieve a desired goal and (2) outcome expectancy as "a person's estimate that a given behavior will lead to certain outcomes" (1977; p. 79). Ashton and Webb (1982) extended the theory to teachers and suggested that the two dimensions could affect actions and decisions independently. Other researchers have continued to work towards a comprehensive theory of self-efficacy. Bandura and Wood (1989) emphasized three aspects of the construct: (1) a "comprehensive summary" of perceived capability to perform a task (Gist & Mitchell, 1992, p. 184), (2) a "dynamic construct" that is subject to change with time and experience (p. 185), and (3) a "mobilization component" that can adapt to fit in complex situations. Self-efficacy has been applied to science teaching with findings that efficacious teachers are enthusiastic about teaching, are more inclined to make pedagogical choices aligned with reform-based practices, and continually work to improve their practice (Appleton & Kindt, 2002; Ramey-Gassert, Shroyer & Staver, 1996).

Sources of Self-Efficacy

Bandura (1997) proposed four major sources of self-efficacy that play important roles in determining self-efficacy expectations for an individual: (1) enactive mastery experiences, (2) vicarious experiences, (3) verbal persuasion, and (4) emotional arousal. Mastery experiences represent a person's experiences of being successful in the past that add to his/her self-confidence to succeed in similar situations and increase coping efforts in challenging situations. In terms of preservice teacher education, mastery experiences that can positively influence science teaching self-efficacy include classroom teaching opportunities (Bandura, 1982, 1997; Bautista, 2011) and writing reflections on one's own teaching (Brand & Wilkins, 2007). Other experiences such as engaging in inquiry-based science investigations, classroom discussions, and creating inquiry-based science lesson plans and implementing those in field have also been documented as productive mastery experiences within the context of science teaching method courses (Gunning & Mensah, 2011; Mulholland & Wallace, 2001; Soprano & Yang, 2013).

Vicarious experiences correspond to beliefs in oneself to succeed after seeing evidence of others being successful in similar situations. Vicarious experiences may include observing other teachers' successful performance in classroom settings or watching videos of teachers using effective teaching models (Bautista, 2011; Gunning & Mensah, 2011). They may also include self-modeling where preservice teachers video record their own teaching followed by reflection or critical evaluation of the experience (Bautista, 2011). Verbal persuasion refers to positive feedback received from others on teaching performance that increases an individual's performance skills. Examples may include preservice teachers receiving positive feedback and encouragement from instructors, peers, school supervisors, mentor teachers, and family support (Bandura, 1997; Bautista, 2011). The fourth source of self-efficacy, emotional arousal, refers to one's physiological and affective states that may influence anxiety and stress levels to further shape an individual's performance. Physiological and affective states of individual teachers may influence their ability to handle stress and anxiety while teaching science and determine how well teachers can handle unanticipated or challenging situations in a classroom (Bandura, 1997; Bautista, 2011; Gunning & Mensah, 2011).

Palmer (2006b) proposed three additional sources of self-efficacy: (1) cognitive content mastery, (2) cognitive pedagogical mastery, and (3) stimulated modeling. Cognitive content mastery is associated with a successful science learning experience. Cognitive pedagogical mastery is associated with the understanding of effective teaching methods and strategies, and stimulated modeling represents role play in which preservice teachers are taught as elementary students in order to experience science learning. Palmer (2006b) argued that mastery and vicarious experiences can take a variety of forms in preservice teacher preparation experiences. Therefore, Bandura's sources may not apply to all contexts. For instance, success in understanding science content (cognitive content mastery) could be as effective in enhancing self-efficacy as enactive mastery experiences (Narayan & Lamp, 2010; Palmer, 2006b). Moreover, important questions persist regarding the relative effectiveness of each of the sources of self-efficacy. Bandura suggested that mastery experiences are most effective, but other studies found that vicarious experiences (watching video cases), instructor modeling (observing successful examples of teaching), and verbal persuasion can have powerful influence on preservice teachers' science teaching efficacy beliefs (Mulholand & Wallace, 2001; Palmer, 2011; Settlage, 2000).

Factors Affecting Science Teaching Self-Efficacy

Numerous studies have utilized Bandura's (1997) or Palmer's (2006b) frameworks of *sources* of self-efficacy to understand the impact of various course interventions as well as the contribution of each source towards changes in preservice teachers' science teaching self- efficacy beliefs. Brand & Wilkins (2007) found that mastery experiences such as learning science content in a constructivist environment and planning and implementing inquiry-based lessons could enhance preservice teachers' self-efficacy within a combined science and mathematics method course. They also found traces of social persuasion such as encouragement by the instructor and peers and stress reduction as sources of self-efficacy. Bautista (2011) found opportunities to teach a science lesson greatly impacted preservice teachers' science teaching self-efficacy. Unlike previous studies, Gunning and Mensah (2011) focused on in-depth analysis of a single case and found that microteaching opportunities and in-class discussions were the two most influential factors shaping the preservice teacher's perceptions of his/herself as a science teacher.

While the studies cited earlier suggest that mastery experiences are important for supporting preservice teachers' science teaching self-efficacy beliefs, other researchers argue that additional sources such as vicarious experiences could be as influential in enhancing science self-efficacy (Bautista, 2011; Settlage, 2000). Watching video cases of expert teaching is widely used and can be an effective source of self-efficacy. Yoon et al. (2006) found that watching exemplary video cases of effective science lessons allowed preservice teachers to establish meaningful connections between theoretical knowledge and practical application of it. Consistent with this finding, Settlage (2000) found watching videos on learning cycle as an instructional strategy had positive effects on preservice teachers' outcome expectancy beliefs. Bautista (2011) also found that vicarious experiences such as watching video case studies or in-class discussions on an instructional strategy were important sources of science teaching self-efficacy.

Studies on self-efficacy conducted in the context of science content courses are relatively less in comparison to the literature on studies on self-efficacy within the context of science method courses. Most of these have measured changes in science self-efficacy as preservice teachers engage in a science content course (Velthuis, Fisser & Pieters, 2014); only a few explicitly focus on investigating content course-related factors that may shape self-efficacy beliefs. Narayan and Lamp (2010) focused on exploring factors influencing preservice teachers' self-efficacy in a physical science course built around constructivist and inquiry-based teaching approaches. Participants reported an increase in their self-efficacy beliefs through engagement in inquiry-based activities and modeling of appropriate practices by the course instructor. In another study conducted by Knaggs and Sondergeld (2015) within the context of a science content course, science instructor's modeling science pedagogies was an important factor to support preservice teachers' self-efficacy. In a more recent study by Palmer (2015), positive changes in preservice primary teachers' science teaching self-efficacy were noted after their participation in a science content course as well as 10 months after the course concluded. Participants indicated that understanding of science concepts, learning how to teach primary science, and teachers' enthusiasm were factors that supported positive changes in self-efficacy.

Methodology

This study utilizes qualitative methods with an embedded quantitative component for identifying groups of participants (details on participant groupings are provided in subsequent sections). The methodological approach used is based on grounded theory (Strauss & Corbin, 1988) to explore meanings that experiences hold for individual participants. This research occurred in two phases: an initial quantitative phase where a self-efficacy pre-test was administered as a means of selecting participants and a second phase in which qualitative data were collected and analyzed to identify factors that support changes in science teaching self-efficacy beliefs.

Research Context

This study was conducted in a specialized physics content course designed for early childhood and elementary education majors at a large Midwestern university in the USA. Given that elementary teachers are less comfortable with physical science and traditional physics courses taken by education majors often fail to provide the type of preparation required for teaching elementary physical science effectively (Banilower et al., 2013; McDermott, Shaffer & Constantinou, 2000), we chose to explore sources of self-efficacy within a specialized physics content course context. The semester-long course focused on preparing preservice teachers to teach basic physical science topics aligned with the K-6 science curriculum such as electricity, magnetism, force, and motion. The course was structured in a combined lecture-laboratory format with the purpose of enhancing preservice teachers' science conceptual understandings and problem-solving skills. Students participated in inquiry-based investigations, collaborative teamwork, and group discussions. Each unit was divided into smaller instructional modules taught through the 5E (Engage, Explore, Explain, Elaborate, and Evaluate) learning cycle approach (Bybee, 1997). Students worked in groups of three, participating in small scientific investigations, projects, and group presentations. The class met three times a week for a total of 270 min per week over the course of a 16-week semester.

Participants

The participants in this study were early childhood and elementary education majors enrolled in two terms of the course taught by the same instructor. Of the 62 preservice teachers enrolled, 51 volunteered to participate in the study. Most of the preservice teachers enrolled were in their sophomore or junior years at the university. In order to collect a rich set of data to inform sources of self-efficacy, we chose to purposefully select 18 participants from among the group of 51 volunteers. In order to maximize potential variability among participants' in terms of sources of self-efficacy, we identified preservice teachers with low, medium, and high science teaching self-efficacy beliefs at the beginning of the specialized content course. Each group comprised six preservice teachers, 5 of them were females and 1 male. All participants were 19 or 20 years old, and they all reported having no formal teaching experience prior to entering college.

We identified these groups based on results from the STEBI-B survey (Enochs & Riggs, 1990) administered on the first day of class. The reliability of the instrument was calculated by using Cronbach's alpha. The reliability coefficients for pre-PSTE and post-STOE were 0.80 and

0.63 respectively. Student views on outcome expectancy were not yet established, and this can be accounted for low reliability values for pre-STOE. The low group was defined by students whose scores were in the lowest quartile; the high-group scores were in the top quartile. The medium group was defined as those students with scores between the top and bottom quartiles.

Data Collection and Analysis

Sources of qualitative data included classroom observations, two semi-structured interviews with each participant, and course artifacts. Interviews served as the primary source of data, and the observations and artifacts were secondary sources. The first interview conducted at the beginning of the semester was designed to identify participants' perceptions of science and science teaching from their prior science courses in high school (see Appendix 1 for selected questions). The second interview, conducted 1 – 2 weeks before the semester concluded, was designed to identify course-related factors that contributed to participants' self-efficacy beliefs (see Appendix 2 for selected questions). Both interviews were conducted individually and were audio-recorded and transcribed. In addition, the first author conducted classroom visits twice a week and took field notes. Detailed descriptions of incidents and events taking place in the classroom in real time as well as contextual factors (e.g. classroom culture, teacher interaction patterns, group dynamics) that could influence student learning were recorded. Artifacts included the course syllabus, students' written work, and group projects.

Analysis of the qualitative data occurred in three stages utilizing a grounded theory approach (Strauss & Corbin, 1988). As explained by Strauss and Corbin (1988), "theory" is conceptualized as set of themes or categories developed through rigorous and systematic analysis to explain the phenomena being investigated. Grounded theory was well suited for this study as the analysis process offered flexibility for the emergence of themes from the data rather than starting with pre-existing categories. First, the interview data were analyzed through open coding for initial themes. These themes were then grouped to generate categories followed by a second phase of analysis using a process of axial coding. Axial coding allowed reassembling of the data and establishing relationships among categories. The second author independently coded a subset of interview data to cross check the emergent categories. Other procedures for establishing trustworthiness included prolonged engagement with the participants, peer debriefing, and data triangulation. Once the categories from interview data were generated and applied to each participant, we employed a cross-case analysis to explore differences within and across cases (Yin, 2003).

The final step of the qualitative analysis involved theoretical comparisons in which data were revisited and reviewed to compare events and incidents within and across categories. This process allowed us to condense categories or generate new categories until saturation was reached. The theoretical comparisons were also informed by the existing literature. For the analysis of observation and artifact data, we purposefully looked for evidence supporting or refuting themes that emerged from the interview data. This process enabled triangulation of the findings for a deeper understanding of the complex phenomenon being explored in the study.

Results

Contributors to Science Self-Efficacy Beliefs

The first research question aimed to identify factors associated with the specialized physics content course that contributed to participants' improved science teaching self-efficacy beliefs. Four major categories emerged from the cross-case analysis as contributing factors for changes in participants' science teaching self-efficacy beliefs. These categories are (1) enhanced science conceptual understandings, (2) active learning experiences, (3) teaching strategies, and (4) instructor role model. **Figure 1** displays the list of categories and their connections to self-efficacy. The expressions of factors supporting participants' self-efficacy beliefs were evident by the ways in which preservice teachers discussed their increased confidence to teach science, positive shifts in attitudes towards science teaching, and their future plans to implement ideas that supported them in their science learning (all constituting dimensions of self-efficacy according to Bandura's framework).

The categories are described in greater depth in the following with interview excerpts (phrases are italicized to emphasize key points). For

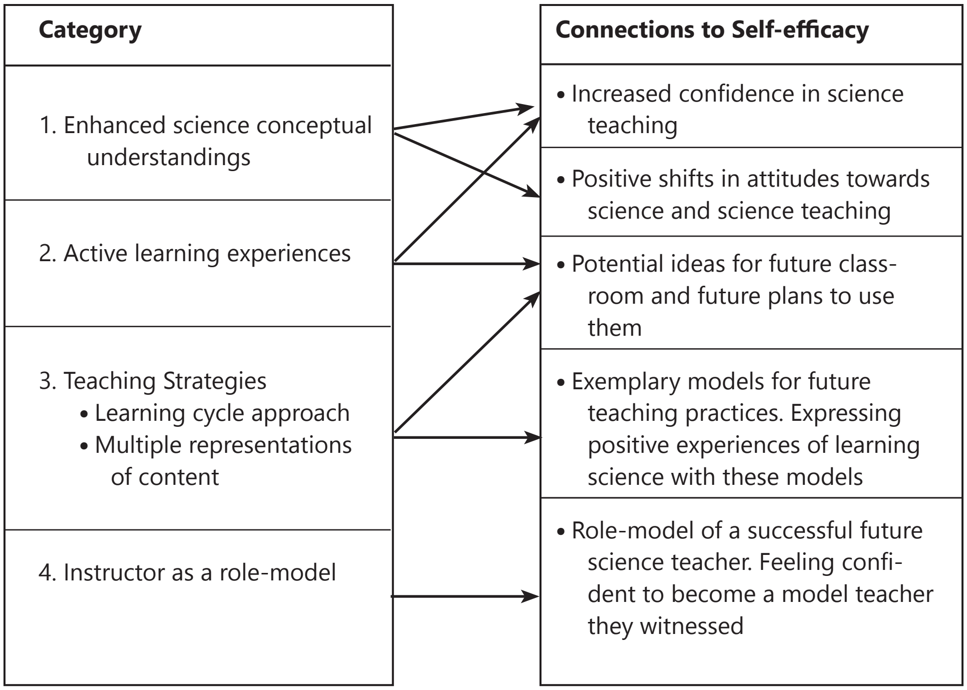

Fig. 1 Course factors associated with promoting self-efficacy beliefs

each interview excerpt, the individual, group (high, medium or low), and data source (first or second interview) are reported. For example, 2L-2 refers to the second interview with the second participant in the low group.

Enhanced Science Conceptual Understandings and Increased Confidence

A majority of the participants from all three groups (low, medium, and high) explicitly stated that they had better and deeper understandings of physics concepts taught in the course. Such improved science content understandings facilitated their gains in confidence for science teaching. As one low-group participant said, “I feel confident on the content that we learned in our physics class. I feel like I could re-teach all of it to other people as I thoroughly learned it” (4L-2). Time spent on science activities and grade-appropriateness of the content were two important factors. The participants mentioned that they felt more prepared to teach science content because of the pace at which learning progressed and the content taught was relevant for future elementary teaching. For instance, one participant from the medium group shared, "I think I could definitely teach an awesome unit on how to light a bulb because we spent so much time on it" (1M-2). Another participant from the low group mentioned that "the class took time to understand the content at a better level which would make sense for people or teachers" (5L-2). Participants' comments also indicated that enhanced science understandings improved their ability to address students' questions in the future. As one participant said, "Course made me understand it [physics content] in more depth …like if a kid would ask me a question, I would know how to answer it" (6L-2).

Enhanced Science Conceptual Understandings and Positive Shifts in Attitude

Participants' responses indicated changes in their attitudes towards science and science teaching. A majority of participants explicitly stated that the ways in which physics content was taught helped them realize the relevance of science in their lives, and thus, they felt more connected to science. For instance, one participant shared how learning about forces in everyday life helped her see science differently. She expressed that she is more likely to include science topics taught in the course in her future teaching:

> Before I did not know forces and motion and what types there were, like normal forces and gravity and so now I know there is always a force of gravity on us. I guess I feel like beliefs have changed …like science is a big part of teaching and it's in a lot more things than I thought before. I like science more now because I know more about it. (2L-2)

At the beginning of the course, many participants indicated that they were scared of physics, but afterward felt positive about physics: "I feel like I have opened my mind more than before. Being able to think about physics definitely opened my mind. Yes, it's not the worst subject of the world anymore" (1M-2). Not only did the participants' attitudes towards physics changed, their comments indicated that they became more willing to teach physics. As one participant stated, "I kind of *had negative feelings towards physics*. Now, I know all this stuff that I did not know before. So I think *it would help me in the classroom* like with the circuits" (2H-2).

Active Learning Experiences Increased Confidence and Provided Potential Ideas

Participants from all three groups talked about the benefits of the active learning strategies showcased in the course. Their descriptions included hands-on activities, working in small groups, problem solving, using real-world examples, and using technology-based simulations. For many low- and medium-group participants, the course was their first exposure to hands-on activities, which represented novel experiences relative to their prior science classes. They suggested that these experiences helped them to develop as independent thinkers and introduced them to more effective ways of teaching science. When asked to elaborate on ideas for future teaching, one participant emphasized that "the hands-on activities are going to make elementary students excited about science and about learning" (3L-2). Participants also mentioned real-world examples used in the course and how these examples can be motivating for elementary students. For instance, one participant discussed ways in which course materials related to an everyday experience: "how gravity acts on us or the forces that act on us when we sitting in a bus" (4M-2).

Participants seemed to benefit from the use of technology-based simulations of physics contents (many of which were drawn from PhET https://phet.colorado.edu/). They elaborated that the simulations provided concrete examples to help future elementary students build science understandings. One participant highlighted ways in which the simulations allowed them to learn through failure, allowing them to see things that worked and, importantly, did not work:

> She [the instructor] had us almost set up for failures in some of the experiments just so we could see what works and does not work and I think that was pretty cool. And also on the computer with the PhET simulations where it would light the battery and fire …I think in an elementary school the kids would think that was really cool but then they would also know it's dangerous so they can figure out what's right and what's wrong easily. (1M-2)

Participants from all three groups were positively influenced by working in small groups, and they saw collaborative learning as an effective strategy for their own future classrooms. Most participants reported that they felt comfortable "being involved with peer groups sharing ideas" (5M-2), critiquing (and being critiqued by) peers that they could trust, and presenting their evidence-based findings to the larger group. They mentioned that "explaining concepts to their peers was a good practice" (5M-2) for their future teaching and that working collaboratively had two benefits for their future classroom—the "students who have higher understandings can help the kids who are struggling" (5H-1) and at the same time helps kids at higher levels can practice what they learned while helping their peers understand.

While many of the low- and medium-group participants were impacted by new experiences with science investigations firsthand, only the high-group participants talked about these experiences in terms of knowledge retention. High-group participants suggested that inquiry experiences would help them retain their content knowledge for a longer period of time and that this retention would lead to more effective teaching. One participant said, "Having all the hands-on activities I feel like I will keep this knowledge for a longer because I have the experiences that I can tie it back to…to hope that other students would also be helped" (2H-2).

Teaching Strategies as Exemplars for Future Science Teaching

Participants also described teaching strategies, such as learning cycle and multiple representations of content, which provided them with examples of successful pedagogical models for future teaching. Several participants indicated that the class was set up like a "modeled classroom" in the same way that they would teach future elementary students. For instance, one participant said, "She [the science instructor] runs the classroom is kind of runs like a model, like how we would run a classroom" (4M-2).

Learning Cycle

Participants suggested that the instructor's consistent use of the learning cycle was a helpful model for their future teaching. One participant said, "I really liked how she does learning cycles everyday … like how there is a question and then we talk about it. I really think that is an effective way to teach" (4H-2). Some participants from the low group mentioned that they saw more benefits associated with teaching through the learning cycle as opposed to more traditional approaches.

Participants mentioned that they liked the step-by-step investigation that the learning cycle offered towards building their understanding of the science concepts. As one participant said, “I thought that was an interesting thing that we did not necessarily go by the book, but we went by the learning cycle, so the way that it was taught helped me think like as if you as a teacher want to get students excited” (6L-2). Several other participants echoed that the learning cycle provided clarity as to *why* they are learning *what* they are learning, so they believed that their future students would also be able to learn by the learning cycle approach.

Multiple Representations of the Content

Participants from all three groups appreciated that the instructor showed concepts using multiple representations. Such experiences of witnessing their instructor addressing the needs of *all* students in the course with different learning styles, the participants from all three groups stated that they were more likely to use different representations while teaching science in the future. They saw potential for this strategy to reach the needs of diverse learners in their own future classrooms. As one participant said, “It prepared me to adjust and try different methods to teach, so I think whatever the students’ needs are, you are to be able to meet them in whatever way is best for them” (5H-2). Furthermore, participants talked about a variety of alternative examples that the instructor used such as drawing diagrams on the large whiteboard, showing science demonstrations such as an electroscope to explain static electricity, or a science video for students to see and hear. These experiences of instructor modeling multiple representations helped participants experience successful ways to meet all students’ learning needs in their future classrooms.

Participants also had opportunities to demonstrate their understandings through multiple representations by creating group artifacts. During the lessons, preservice teachers had opportunities to create posters in small groups and then present them to the class. For instance, in one task, students were asked to make posters showing examples from daily life to represent models of circuit flow. Some students saw these poster-making opportunities as a means for their future students to develop creativity in science. As one participant said, “I did like how we made the posters. I think that’s good that they [future students] could get their creative sense in science" (3M-2). Whiteboarding and poster presentations were strategies that they saw as useful techniques for their future classrooms. One participant explicitly referred to her future teaching as she said, "I feel like I could have stronger class due to the whiteboard like [we used]" (1M-2).

Instructor as a Role Model

The course instructor served as a positive role model for all participants, and her approach seemed to positively affect the preservice teachers' views about science teaching. The participants described three specific attributes of the instructor: her enthusiasm for science teaching, questioning strategies and explanations, and genuine interest in student learning. Many students saw their instructor as an ideal science teacher. One participant said, "she was a good influence because that's what makes a good teacher: being there for your students and answering questions. So, I hope I could be like that too" (1L-2). Several participants realized that the instructor's energy could get them excited about the topic, so now they could influence their future students to learn science as well. As one participant shared:

> She was very excited about the subject and I was not originally but her getting excited about the little less things kind of made me and my group more interested because we wanted to know why it was so exciting. If I go in [refers to future classroom] with just as much excitement as her …I know the right way to teach it. (1M-2)

For many of the low-group participants, the course represented their first experience with a science teacher who was enthusiastic about the subject. Low-group participants also felt that the instructor created an environment in which they were not afraid to ask questions, which was a different kind of atmosphere than they experienced in other science classes. As one participant said, "The instructor is very good at listening to my weird, unorganized questions and coming up with an answer. Seeing a teacher have this knowledge who could answer my questions and provide solid examples…that helped" (2M-2). The participants indicated that the teacher attended to individual questions while circulating in the classroom, which helped some shy students who did not want to speak to the whole class. As one participant mentioned, "I felt like it was good that she came up to all of us individually, because some people don't like to ask questions in a big group. So doing that in the classroom I think would help some students learn better" (2H-2). The instructor treated all students as if they were already teachers, and thus, every students' opinion and ideas were respected. As one participant said, "She did not talk to us and treat us like …we are her students. She talked to us like we are teachers already" (3H-2).

Persistent Challenges

It is clear that the course experiences resulted in positive shifts in self-efficacy beliefs of participants across all groups. However, when asked, most participants shared concerns that they still held about their future science teaching. The four major challenges identified by participants were transforming content for an elementary classroom, self-doubt on content preparedness, long-term impact of the course, and handling the complexities involved with classroom teaching.

Transforming Content for an Elementary Classroom

The major challenge identified by participants was uncertainty about how to transform the content learned in the course into lessons relevant for elementary learners (see **Table 2** for representative excerpts). Even though a majority of participants realized that the course was not directly focused on how to teach, they expressed the need for being able to discuss more about how the activities that they conducted (as a means of supporting their own learning of physics) would look like in an elementary classroom. Participants expressed concerns about whether the activities that they performed in the course, along with the pace of the content, would be a good fit for elementary learners. Some participants also mentioned the lack of opportunities in the course for them to be able to plan and create elementary science lessons on their own based on the topics learned in the course and to be able to teach it to their fellow classmates. A lack of first-hand science teaching opportunities in the course led the majority of low-group participants to question the direct applicability of the science lessons learned in the course for their own classrooms.

Table 2 Transforming content for an elementary class as a challenge posed by participants

Transforming content for an elementary classroom	*Representative excerpts*
Low group	*I wish that there were more opportunities* … more often we *talk about specifically an elementary student* … like you may run into this issue in your classroom when your student asks this kind of question. I know that that's something that I would run into in my next … how to teach elementary science course but that would have been cool specifically for physics the stuff we learned getting like a circuit to light a light bulb then *how could an elementary student do the same thing.* (3L-2)
Medium group	It would have been nice to *may be design a lesson of our own and see and teach it to our peers.* There were a lot of times when people did not understand things and I felt that I can may be explain it to them and may be that would have benefitted me. (2M-2)
High group	I feel like a lot of this class … *I feel like it would all go over elementary kids' head, they are not going to need to know this* or they are not ready to learn this. So *the hard part of me is to…I do not want to say dumb it down but get it back down to an elementary level.* (4H-2)

Self-Doubt Regarding Content Preparedness

One of the most consistent concerns expressed by participants from the low and medium groups was self-doubt related to their content preparedness—whether their content knowledge was enough to explain science concepts to their future students (see **Table 3**). The fear of encountering unanticipated questions from future students, unsure of providing satisfactory responses to questions, and whether they could provide in-depth explanations on science topics were of continuing concern for the low- and medium-group participants. The low-group participants also mentioned their concerns with the amount of time spent on investigating specific science topics, which they believed to be less than what they thought was effective. For instance, they expressed the desire to be able to explore forces and their effects in a greater depth to be able to develop sufficient understandings rather than rushing towards the end due to time constraints. Conversely, responses from the high-group participants frequently indicated high content understandings.

Table 3 Self-doubt on content preparedness as a challenge posed by participants

Self-doubt on content preparedness	*Representative excerpts*
Low group	Because *I do not want to teach anything that I do not know I am doing correctly* or a having a background where I could feel confident teaching someone else or the entire classroom. *I do not like to have to act like I know more than I really do* ever. (5L-2)
	I feel like some of the concepts …*maybe we could have gone more in depth or spend longer time* learning them. I liked the content that we learned but *we did not go very deep* into a lot of the concepts like forces. (4L-2)
Medium group	I think I am going to teach elementary…I think there is just going to be so many questions. *Some student might just ask me a question that I just have no idea about.* They might think of just random questions that I really just won't know the answers to it…that I don't have the knowledge for…*I don't want them to think that I am not credible in science.* (3M-2)

Complexities Involved with Classroom Teaching

Participants from all three groups were concerned about teaching science in an elementary classroom, which they described as a complex environment, and indicated some hesitation regarding their preparedness to deal with these complexities (see **Table 4** for representative excerpts). Some of the complexities involved with classroom teaching described by the participants included handling students' behavioral issues, failure of activities to go as planned or unanticipated experimental results, failure of technology, and lack of supplies or resources to conduct activities. The participants' responses clearly indicated their hesitation to confront some of these complexities involved with future science teaching. The participants said that they wanted to discuss (1) more examples and specific issues involved in elementary teaching, (2) ways in which certain activities could pose more challenges for different kinds of elementary students, and (3) strategies to prevent chaos when encountering unanticipated results from experiments or if an activity failed during a class session.

Long-Term Impact of the Course

Some participants from the low and medium groups were concerned about the long-term impact of the course. Comments from the low- and

Table 4 Complexities involved with classroom as a challenge posed by participants

Complexities involved with classroom	*Representative excerpts*
Low group	I guess if there is just like *one teacher and so many students*…how can that be. *How can we prevent chaos from happening* …I wish that there were more opportunities …more often we talk about *specifically an elementary student* …*like you may run into this issue* in your classroom (3L-2)
Medium group	*I don't think in all elementary schools will have as much supplies* or as many supplies that physics building probably has right here so that we can just go back and find a different activity so I feel like it was almost unrealistic how much stuff that you guys had to do experiments with and so I think it did not prepare us in a way that *we would not have all the supplies so it would be harder to make as many activities* I guess (1M-2)
High group	There are challenges that you can face, some of the *technology may not work*, you may not have all the material so you have to improvise and make the best of all the situation. (4H-2)

medium-group participants implied that they had concerns with knowledge retention—whether they would be able to retain all the content and specific activities learned in the course by the time that they are teaching. As one participant said, "I feel like I might forget the little stuff [physics content]. I still do not know if it would come as super natural so I do not know if I would be the best at it [science teaching]" (6L-2). Another participant from the medium group raised similar concerns about the time lag between the content course and her teachings: "If I had space in between this class and teaching then I probably would not be as effective." Her major concern was that unless the ideas learned in the course are reinforced, she may forget examples, specific activities, and discussions on how things worked and that might decrease her efficacy to teach. She continued, "I do not think I would remember exactly what did not happen or…what was the best example to explain it and that would make teaching more difficult. I think knowledge needs to be reinforced" (1M-2). This pattern was not observed among the high group; rather, the high-group participants talked about retaining content knowledge for a longer period of time.

Discussion and Implications

Factors Supporting Self-Efficacy Beliefs

This research was designed to explore factors supporting development of science teaching self-efficacy beliefs for preservice elementary teachers who held diverse levels of self-efficacy beliefs. The evidence strongly suggested that course experiences helped participants to become more comfortable and confident to teach science. This finding is in accord with the study conducted by Palmer (2015) where increases in understanding of science concepts were an important factor contributing towards increases in self-efficacy beliefs. The findings of the current study, suggesting improved self-efficacy, support the notion that engaging preservice teachers actively in science learning is important for them to develop an appreciation for science and science teaching (Bergman & Morphew, 2015; Kazempour & Sadler, 2015; Menon & Sadler, 2016a; 2016b). Other factors such as the time spent on science activities, grade-appropriate science topics, and the pace at which learning progressed were valuable in developing deeper understandings of physics content relevant for their teaching. It is expected that offering opportunities to experience science consistent with the ways that they are expected to teach will result in positive effects on elementary preservice teachers' science teaching self-efficacy, especially for low-efficacious students as found in this study. Such positive experiences of learning science emerged as what Palmer (2006b) described as *cognitive content mastery* and had a powerful influence on participants' science teaching self-efficacy.

The course utilized several pedagogies such as hands-on learning, group discussions, white boarding, and computer simulations, which proved to be beneficial. According to Palmer (2006b), use of effective pedagogies provides rich sources of *cognitive pedagogical mastery* experiences and can contribute to science teaching self-efficacy. This was articulated by participants that they benefited from the learning cycle approach and multiple representations of content and that these strategies provided ideas for science teaching. Participants, especially from low and medium groups, found that doing science helped improve their attitudes towards science. This is in accord with the literature that suggests that engaging preservice teachers in science through appropriate pedagogies helps them appreciate science (Gunning & Mensah, 2011;

Leonard, Barnes-Johnson, Dantley, & Kimber, 2011). The findings support the notion that witnessing successful science teaching (*vicarious experiences*) or experiences with "activities that work" have a similar potential to enhance preservice teachers' science teaching self-efficacy as Bandura's mastery experiences (Palmer, 2006b; Yoon et al., 2006). Furthermore, the findings of this study concur with other studies that found that courses structured around constructivist approaches and modeling effective pedagogical strategies were as effective in enhancing preservice teachers' self-efficacy beliefs as courses built around providing enactive mastery experiences (Palmer, 2006b; Bautista, 2011).

The course instructor's enthusiasm and positive approach towards science teaching also shaped participants' perceptions of a successful science teacher. The social persuasion and encouragement provided by the instructor had an influence on participants' affective and psychological states. In fact, many remarked about the classroom environment as a fun and non-intimidating learning environment. This finding is particularly important given the setting of the study, a physics course. Preservice elementary teachers have historically struggled in undergraduate physics courses, which seems to have contributed to a lack of attention to physical science teaching in elementary classrooms (McDermott, Shaffer & Constantinou, 2000). In the case of this study, the participants mentioned that the science classroom itself felt like a "model for an elementary classroom" that they could expect for themselves in future. This experience, described by Palmer (2006b) as *stimulated modeling*, contributed positively towards participants' science teaching self-efficacy. This finding is consistent with other studies that found that course instructors' behavioral patterns influenced preservice teachers' self-efficacy beliefs and attitudes towards science teaching (Ramey-Gassert et al., 1996; Rice & Roychoudhury, 2003).

Previous research suggests that self-efficacy beliefs are developed in science method courses (Bautista, 2011; Rice & Roychoudhury, 2003). The results of this study support the conclusion that science content *course-related* factors can promote development of science teaching self-efficacy beliefs. An important implication is that instructors involved in preparing preservice elementary teachers should place greater emphasis on selecting appropriate science activities and modeling effective pedagogies within science content courses. More time should also be spent helping prospective teachers see science as relevant for their future teaching. It is particularly important for classroom environments to be fun and engaging, especially when it comes to physics content courses, and particularly for students who come from relatively poor science backgrounds. If science content courses are offered within content departments, then designing science content courses should be a collaborative effort between the science faculty and science education faculty. Such collaborations would ensure an environment that delivers high-quality science experiences, along with modeling of evidence-based science teaching practices, for preservice teachers to develop science teaching self-efficacy early on for their future teaching career.

Addressing Persistent Challenges

The study has identified challenges that continued to affect preservice teachers' perceptions of science teaching. The data revealed that some participants from the low and medium groups continued to express concerns regarding their preparedness in science. It is not uncommon for preservice teachers to begin college with limited science knowledge that continues to affect their perceptions of themselves as a science teacher (Yoon et al., 2006). One would expect that college science content courses would help build science content knowledge. However, the fact that weaknesses in science content knowledge were of continuing concern for some participants suggests that additional support is necessary to gain confidence needed for future science teaching. This can be achieved by reinforcing appropriate science content in ways that they are expected to teach in science method courses. Furthermore, recognizing that lack of confidence in science may interfere with feelings about one's abilities to teach science, science classes should be structured to include elements that could address these challenges. Purposeful selection of science experiences within the science content courses can influence students' perceptions regarding their ability and confidence to teach science (Ramey-Gassert et al., 1996).

Other impediments to the development of participants' confidence resulted from a lack of knowledge of how to teach in an elementary classroom. The content course did not intend to focus explicitly on "methods" of teaching science; therefore, it is reasonable to believe that group participants did not make explicit connections on how to transform content for an elementary classroom. However, several effective pedagogical models for teaching science content, such as the learning cycle and multiple representations of the content, were utilized in the course. Perhaps holding discussions within content courses on how some of these pedagogical models can be successful, for elementary science teaching would help preservice teachers to make connections between these experiences and future science teaching.

Another pressing concern among all participants was “fear of failure” in their future classrooms. Participants expressed concerns regarding failure of activities to go as planned, managing student behaviors during hands-on activities or otherwise, and responding to student queries on science topics. These concerns, if not sufficiently addressed, may continue to affect their science self-efficacy beliefs that will then be carried to other stages of their teacher preparation. Other studies have noted similar concerns among preservice teachers who have not completed student teaching (Brand & Wilkins, 2007; Gunning & Mensah, 2011). One way to address this within science content courses is to have preservice teachers collaborate and design at least one science lesson on the topics learned in their science content course and practice teaching to their peers. Any experience of practicing science teaching is beneficial (Mulholland &Wallace, 2001) and may also help in smoothly transitioning into teaching method coursework and student teaching.

Finally, although preservice teachers enriched their science conceptual understandings, many mentioned doubts concerning their ability to retain information learned in the course by the time that they arrive in their future classrooms. Of course, it was unrealistic to predict whether or not the study participants would retain their knowledge during their student teaching or in future in-service career at the time of this study. This issue, however, is important for effective science content preparation and retention and certainly needs further exploration. More research is needed to understand the lasting effects of science training on teacher classroom practices. While this raises questions about the long-term impact of science content courses, the positioning of content courses with regard to the overall structure of the teacher preparation program should be considered. If science method courses are the next step in the sequence, science method instructors should provide opportunities to reinforce the science content learned previously, while instructing in “methods” of science teaching. One practical solution would be to offer “integrated” methods and content courses that prioritize specific needs of prospective elementary science teachers. Such integrated science courses should also provide opportunities for preservice teachers to practice teaching in some capacity instead of having them wait until their student teaching practicum to put any of their new strategies for teaching into action.

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Appendix 1. Interview questions (part 1)

1. Do you see yourself as a science teacher?
2. What motivates you to be a science teacher?
3. Summarize your experiences from your high school science classes? (example, how learning happened in your science classes in high school).
4. What were some of the methods your teachers used in your high school science classes? (example, lecture mostly, hands-on experiments, PowerPoint lectures).
5. Please tell the experiences from the science classes in college prior to the physical science content course?
6. Have you taught science before? If so, summarize your teaching experiences?

Appendix 2. Interview questions (part 2)

1. Do you see yourself as a science teacher? Has your view of yourself as a science teacher changed? How? Is this view of yourself one you like? Why? Why not?
2. Do you think your beliefs about science have changed by taking this physics course? How?
3. Describe your experiences in this physics content course that have influenced your beliefs about science? Give an example of something you used to think about science that has changed now?
4. What aspects of the course (example, lectures, teaching models, classroom activities (specify), explanations, assessments) influenced your present beliefs about science? You may describe specific incidents that happened within the course if you like.
5. Do you think your beliefs about science teaching have changed by taking this physics course? How is this change related to this course?
6. Describe your experiences in this physics content course that have influenced your beliefs and confidence to teach science? You may describe specific incidents that happened within the course if you like or you may describe something about how the course was taught that helped you visualize a new way to teach.

7. What aspects of the course do you think (example, lectures, teaching models, classroom activities (specify), explanations, assessments) contributed to your change in beliefs about science teaching? For example, was there something about the way your teacher interacted with the class or with you that contributed to your changed beliefs?
8. Did this physics content course prepare you for the challenges that you may face when teaching science? In what ways do you think the course prepared you? In what ways do you think the course did not prepare you?
9. Do you think your students will be able to learn physics as a consequence of your teaching? Why do you think so?
10. Do you think your science teaching will make a difference in your students' achievement? Why do you think so?
11. What more could this physics content class have done to better prepare you to effectively teach science?

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