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The Influences of Socioscientific Issues on General Science Teaching Self-Efficacy

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Abstract
Two common reasons elementary preservice teachers have low self-efficacy with science teaching is their lack of content knowledge and past negative experiences with science teaching or learning. Holding low self-efficacy beliefs has negative impacts on both the method of science instruction and amount of science instruction delivered in the elementary classroom. Many researchers have successfully explored methods for improving elementary preservice teachers' science teaching self-efficacy by providing positive, inquiry-based learning experiences during a science methods course, but the present study explores how to improve elementary preservice teachers' science teaching self-efficacy beliefs by engaging them in socioscientific issues (SSI) during their elementary methods course. Using a mixed methods approach, we collected quantitative with the science teaching efficacy beliefs instrument part B (STEBI-B) and qualitative data through short answer responses focused on understanding their perceptions and confidence with science instruction. Our analysis of the qualitative data focused on identifying the influences for any change that resulted from the STEBI results. Our findings illustrate SSI as a commonly identified reason for positive changes in general science teaching self-efficacy. Implications for utilizing SSI as an approach to combat low science teaching self-efficacy are discussed.

Keywords Socioscientific issues · Preservice teachers · Self-efficacy · Elementary science teaching

Introduction

Teachers' self-efficacy beliefs, or confidence in their teaching abilities, form mostly during their tenure as preservice teachers (Ilhan, Yilmaz, & Dede 2015). The beliefs formed while engaged in teacher preparation programs influence the instructional decisions they make as in-service science teachers (Appleton & Kindt, 1999; Yoon, et al., 2006). Historically, it has been documented that elementary teachers with low self-efficacy in science teaching

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may focus more on facilitating instruction in other subjects, minimizing the amount of science instruction children receive (Appleton & Kindt, 1999); while those with high self-efficacy will emphasize hands-on learning experiences and engage in a student-centered approach to science instruction (Trauth-Nare, 2015; Yoon et al., 2006).

A lack of interest in science due to negative learning experiences as a student has been reported as a source of low self-efficacy in science teaching (Cervato & Kerton, 2017). Additionally, preservice teachers have attributed low self-efficacy to a lack of science teaching experience and content preparedness (Menon & Sadler, 2016). Preservice teacher preparation programs have the opportunity to provide the space for these negative perceptions toward science to change (Kırık 2013). Therefore, science methods courses are a plausible venue for teacher educators to provide positive science learning experiences through modeling pedagogical strategies while also improving content understanding.

Socioscientific issues (SSI) instruction is a pedagogical approach to science teaching that engages students in open-ended problems that are controversial in nature with no clear solution, requiring the application of science content knowledge and nature of science skills as students cultivate understandings of perspective taking/empathy, scientific discourse, and moral/ethical considerations to develop evidence-based, informed decisions regarding the issue (Sadler, 2011; Zeidler, 2014). Empirical evidence concerning the implementation of SSI in the classroom illustrates an increase in understanding science content knowledge (Sadler et al. 2016), improved decision-making skills (Rundgren et al. 2016), and informed views of nature of science (Walker & Zeidler, 2007). Due to the complex nature of SSI, these benefits have been found in secondary and post-secondary contexts with limited enactment in the elementary context. We find this to be unfortunate for elementary preservice teachers and sought to design an elementary science methods course that would expose preservice teachers to this pedagogical approach.

The present study explores how the incorporation of elementary-based SSI instruction in a science methods course influences elementary preservice teachers' science teaching self-efficacy as well as their perceptions and confidence with teaching SSI in future classrooms.

Theoretical Frameworks

Science Teaching Self-Efficacy

Self-efficacy, or beliefs one holds about their abilities to perform a task, are known to be influenced by four factors: mastery experiences, vicarious experiences, social persuasion, and physiological or affective responses (Bandura 1977, 1994). With self-efficacy focusing on one's beliefs about their abilities, the terms efficacy and confidence are often interchangeable in the literature and studies emphasizing efficacious views often use data collection that focus on participants' confidence levels (e.g. Usher et al. 2019). Positive mastery experiences occur when a person performs an action and experiences success with that action. In preservice science teacher education literature, this often occurs during microteaching episodes that occur in a methods course (Gunning and Mensah 2011), field experiences in which teacher candidates facilitate instruction to their students (Flores 2015), or when they participate in a science lesson and replace past negative experiences of learning science with new, positive experiences (Avery & Meyer, 2012). Vicarious experiences occur when one observes another perform a task successfully and have been identified as influential when preservice teachers participate in an effective science lesson that occurs during a methods course. For instance, Kazempour and Sadler (2015) noted how preservice teachers who initially had low confidence in their abilities to teach science became more confident after vicarious experiences in which instructional strategies were modeled during a methods course. The main difference between mastery and vicarious experiences is during mastery experiences one is actively engaged in an activity while during vicarious experiences someone, perhaps an expert in the field or someone who is more advanced, is observed performing a task. Both social persuasion, which is defined as verbal influences on one's confidence, and physiological or affective states, which are influences on confidence due to emotional responses, are found to be impacted by feedback on one's practice. In a study focused on utilizing action research to improve preservice teacher confidence with science instruction, Kinskey (2018) acknowledged how impactful the feedback from a collaborating teacher was on the self-efficacy and reflective practice of a preservice teacher. Additionally, Cinici (2017) found feedback during collaborative microteaching episodes provided positive influences to science teaching self-efficacy through an emotional support network.

While there is evidence for all four sources of self-efficacy to be influential to improving preservice teachers' confidence with science teaching, extant literature often credits mastery and vicarious experiences as the most influential constructs. To explain this, Menon (2020) offers that it is through experiences interacting with science through teaching and learning that provides opportunities for the other constructs to be addressed. For instance, social persuasion through events such as feedback in the form of observing student excitement during teaching episodes would influence positive mastery experiences, while having success while learning science content may help overcome any negative emotions that may have been present.

Science is historically perceived as a subject area heavy in content and vocabulary and lacking creativity (Ramey-Gassert & Shroyer, 1992). This perception of science often contributes to elementary preservice teachers' low efficacious views of themselves as they are fearful of their lack of science content knowledge and ability to facilitate science instruction (Menon & Sadler, 2016). When preservice teachers do not have high levels of self-efficacy, they often result to scripted curriculum, are less willing to take risks in the classroom (Ramey-Gassert & Shroyer, 1992), and teach a minimal amount of science (Yoon et al., 2006). High self-efficacious preservice teachers, however, are more likely to explore with new methods of instruction (Ramey-Gassert, Shroyer, & Staver, 1996), hold informed views of nature of science (Akyol, Tekkaya, Sungur, & Traynor, 2012), and incorporate scientific inquiry-based practices (Watters & Ginns, 2000).

Ramey-Gassert, Shroyer, and Staver (1996) argue if science methods instructors are to move preservice teachers toward having high levels of self-efficacy, they must begin to incorporate non-threatening teaching strategies into their methods courses. Non-threatening teaching strategies are those that do not create environments where preservice teachers are fearful of being incorrect or making a mistake. These non-threatening teaching strategies may stimulate situational interest in a specific area of science teaching (Palmer et al. 2017). In the present study, this was taken into consideration during the design of an elementary science methods course, which intentionally consisted of non-threating strategies that fostered open-ended, collaborative learning experiences, such as SSI.

Socioscientific Issues Instruction

When teachers facilitate science instruction that includes SSI, they are engaged in student-centered science teaching that provides opportunities for students to drive their own instruction as they grapple with open-ended, real world, societal-based problems that have no clear solution (Sadler, 2011; Zeidler 2003). The SSI framework includes nature of science, perspective taking/empathy, scientific discourse/argumentation, and moral/ethical considerations (Zeidler & Kahn, 2014). Implementation of each aspect of the SSI framework is outlined in Table 1.

While empirical evidence regarding the influence of SSI on general science teaching self-efficacy does not, to our knowledge, currently exist, research concerning preservice teachers' perceptions on teaching SSI in the elementary context reveals low-efficacious causing concerns regarding views of NOS (Kılınç et al. 2013), lack of content knowledge connected to the issue (Forbes & Davis, 2008), knowledge of SSI pedagogy (Pitiporntapin et al. 2016), and confidence in their abilities to teach SSI (Kılınç et al. 2013). Empirical literature regarding engaging preservice teachers in SSI, however, has addressed many of confidence-defeating concerns.

For instance, after engaging 63 elementary preservice teachers with SSI concerning global climate change during a science methods course, Hestness et al. (2011) noted their students had an increase of confidence with teaching content connected to the issue of climate change and argue that engaging preservice teachers with SSI improves their abilities to utilize analytical approaches to science instruction and navigate various resources for teaching real-world science concepts. Similar findings were identified by Saunders and Rennie (2013) when they engaged four teachers in a series of workshops focused on providing a model for ethical inquiry that would be used to guide their SSI instruction to high school students. Their findings identify the positive influence a structured model has on improving educators' instructional practice and confidence with enacting SSI lessons.

Purpose of the Study

Our goal as preservice teacher educators is to ensure our students are confident in their abilities to teach effective science instruction that is relevant to the lives of their elementary students. As many goals of current reform efforts focus on improving science instruction

Table 1 Instruction with the SSI framework

Constructs of SSI	What it looks like during instruction
Nature of science	Students are explicitly told how they are acting as a scientist as they engage with empirical evidence, collaborate with others, and discuss their opinions. The nature of engaging with the societal problem, provides opportunities for students to understand how science is socially and culturally embedded
Perspective taking/empathy	Students consider how various communities are impacted by the different solutions proposed to the problem. Students learn about the effects the issue has had on different societies and consider these effects when developing their own opinions. Sometimes students are assigned a specific lens with which to look at the problem through, allowing themselves to be placed "in the shoes" of that member of society to deepen their ability to display empathy
Scientific discourse/argumentation	Students apply their understanding of the science content associated with the issue and the various perspectives to develop an informed opinion and argue their opinion with peers
Moral/Ethical considerations	Students consider all the information they have from their resources, peers, and personal experiences to identify what they believe is the right decision to make

regarding elements of the SSI framework (i.e. scientific discourse, moral considerations, problem solving, real world connections), we argue that SSI instruction is essential to elementary science teacher education and choose to emphasize this pedagogical approach in our methods courses. From the literature, however, we know a variety of pedagogical strategies taught during science methods courses results in positive science teaching self-efficacy. The purpose of this study, therefore, was to explore what influence, if any, engaging preservice teachers in SSI instruction during their elementary science methods course had on their science teaching self-efficacy. The following research questions guided this study:

1. How do elementary preservice teachers' general science teaching efficacy beliefs change after a semester-long science methods course that includes socioscientific issues?
2. How does engaging with socioscientific issues during an elementary science methods course influence elementary preservice teachers' beliefs about their abilities to facilitate science instruction in the elementary context?

This study is significant because while extant literature has identified science methods courses as impactful in improving elementary preservice teachers' general science teaching self-efficacy and confidence with teaching SSI specifically, the connection between SSI and confidence with general science teaching has yet to be explored. As current reform efforts emphasize a need for preparing teachers to develop scientific literacy skills in students (NRC 2012) it is critical to find a pedagogical strategy to incorporate into teacher preparation programs that will improve preservice teachers' knowledge and confidence with their ability to facilitate science lessons that meet these goals.

Research Design and Methods

To answer our research questions, both quantitative and qualitative data were collected and analyzed using a concurrent mixed methods design. Quantitative and qualitative data were collected simultaneously and were equal in priority. The quantitative data provided the measure of impact or change regarding self-efficacy, while the qualitative data offered insight into the beliefs that may influence the quantitative results. The inclusion of both quantitative and qualitative data collection and analysis provided the opportunity to gain a rich understanding of the influence SSI had on the preservice teachers personal science teaching self-efficacy (Greene, 2007; Hesse-Biber 2010).

The research questions were explored through the collection of pre- and post-surveys of the STEBI-B to collect quantitative data and pre- and post-open ended response questions for the qualitative aspect of the study. Table 2 shows a summary of the data collection instruments of the study.

Context and Participants

Data were collected during a 14-week semester long elementary science methods course, taught by the first author. The methods course met one day a week for 2 h and 45 min. Twenty-two elementary preservice teachers in the junior year of their undergraduate program were enrolled in the course. This course was considered a field-based course, which means while enrolled in the course the preservice teachers also completed one full day of field experience per week.

Table 2 Mixed methods design features

Construct Assessed	Quantitative Survey	Qualitative
Personal science teaching self-efficacy	STEBI-B – (pre/post semester)	
Beliefs about science teaching abilities		Open-Ended Question (pre/post semester)

The elementary methods course emphasized foundational understanding and application of aspects of NOS and the 5E instructional model that were applied through SSI. The structure of the class meeting time, outlined in Table 3, loaned itself to providing the preservice teachers with vicarious and mastery experiences as they observed the methods instructor facilitate science lessons, participated in lessons as students, and developed their pedagogical understandings by experiencing what science instruction should look like.

An outline of how preservice teachers interacted with SSI during the modeled lesson is provided in Table 4. Since this was a field-based course the preservice teachers were expected to apply what they learned about science instruction in their practicum by planning and facilitating a lesson to their elementary students. This experience of teaching provided an opportunity for participants to gain mastery teaching experiences. Social persuasion and affective responses are constructs of self-efficacy we believe occur in an internal fashion, and both course- and field-based experiences could provide these influences.

Data Collection and Analysis

The mixing of quantitative and qualitative data collection and analysis provided opportunities to triangulate the data and findings to increase validity (Greene 2007). As multiple perspectives from the quantitative and qualitative data were analyzed concurrently, findings were compared and contrasted to draw conclusions.

STEBI-B pre- and post-surveys On the first day of the course, the preservice teachers completed the STEBI-B. This instrument was provided at this time to gather information regarding the preservice teachers' initial beliefs about their ability to facilitate science instruction, prior to any course readings or instruction. The survey was developed by Enochs and Riggs (1990) and reexamined by Bleicher (2004) for internal consistency and validity. The STEBI-B measures two constructs: the science teachers' teaching efficacy belief (Personal Science Teaching Efficacy, PSTE) and the expected outcomes from

Table 3 Outline of elementary science methods course structure

Time range	Pedagogical activity
0 – 30 min	Preservice teachers complete a formative assessment focused on content
30 – 60 min	Preservice teachers discuss readings
60 – 150 min	Preservice teachers participate in a modeled lesson: inquiry-based 5E structure, NOS, SSI
150 – 165 min	Preservice teachers complete a lesson analysis and reflection

Table 4 Summary of poisons SSI lesson modeled during class meeting time

Activity	Details	Connection to SSI Framework
Formative assessment: Draw a food chain	PSTs illustrate their conception of a food web	Science content knowledge connected to the issue
Discussion of reading: SSI Background and Introduction (Zeidler & Kahn, 2014)	PSTs respond to the reading they completed prior to coming to class	PSTs preview what they are going to experience in terms of connecting science content to moral/ethical considerations; NOS; perspective taking/empathy; scientific discourse
Modeled 5E lesson (over the course of 2 class periods)	Engage: PSTs respond to "Should people in neighborhoods use poison-based bait to kill rodents?" Explore: PSTs engage in owl pellet dissection investigation Explain: PSTs share findings from owl pellets; discuss their understanding of the food chain, learn key content and vocabulary associated with food chains and food webs Elaborate: PSTs interact with a variety of sources sharing different perspectives concerning the positive and negative effects of using of poison baits in neighborhoods Evaluate: PSTs engage in a debate to argue for or against poison bait in neighborhoods. After the debate, PSTs revisit the initial question and respond again	Science content connections: Content knowledge was developed during Explore and Explain while the knowledge was applied to the issue during Elaborate and Evaluate Nature of science: Explicit connections to NOS were made throughout the Explore, Explain, Elaborate, and Evaluate Moral/ethical considerations: Connections are made during the Engage, Elaborate and Evaluate Perspective taking/empathy: Developed during the Elaborate and Evaluate stages Scientific discourse: Evidence was collected during the Explore, Explain, and Elaborate stages while the skill was applied during the Evaluate
Lesson analysis and reflection	PSTs use a rubric to analyze the 5E model implementation and then use science notebooks to reflect on their experience and learning of the SSI framework	PSTs reflect on each aspect of the SSI framework individually (connecting science content to moral/ethical considerations; NOS; perspective taking/empathy; scientific discourse)

teaching science (Science Teaching Outcome Expectancy, STOE). The STEBI-B was administered a second time on the last day of class as a postsurvey. The purpose of administering the postsurvey STEBI-B was to measure how the preservice teachers' personal science teaching self-efficacy and their outcome expectancy changed after engaging with SSI throughout the course.

The pre- and post-survey results of the STEBI-B were analyzed by running a dependent t-test using SPSS software. The direct-difference method (Coladarci et al. 2014) was utilized with the pre- and post-values from both subscales of personal science teaching efficacy and outcome expectancy, as well as with the composite STEBI-B score. This method of analysis illustrated the degree of change, or lack thereof, in science teaching efficacy beliefs during the semester.

Self-Efficacy Open-Ended Question Immediately after the preservice teachers completed the STEBI-B, they were asked to provide a written response to the following statement: "Explain how you feel about teaching science in elementary school. Explain why you feel this way." Since the STEBI-B is a Likert-type instrument, the open-ended question was administered to provide the preservice teachers the opportunity to more thoroughly express their feelings. The open-ended responses also provided insight into what the preservice teachers identified as influential to the beliefs they held about their science teaching self-efficacy.

While analyzing the participants responses we were interested in identifying any course-based influences, specifically SSI, as well as how those influences connected to Bandura's theory of self-efficacy. We coded with descriptive codes to identify influences from the course as well as codes linked to self-efficacy: mastery experiences (ME), vicarious experiences (VE), social persuasion (SP), and affective response (AR).

Findings

Quantitative findings To determine if the incorporation of SSI had an impact on the preservice teachers' self-efficacy, the quantitative instrument STEBI-B, as well as reflective, open-ended questions, were administered on the first and final day of the science methods course. Descriptive statistics were run on the STEBI-B as a whole, as well as for the personal science teacher efficacy (PSTE) and science teacher outcome expectancy (STOE) subsections. Table 5 shows the results of the SPSS analysis.

From an initial review of the data, it appears that the students appeared to become more confident in their science teaching efficacy as well as the outcome expectancy for their students. To test whether the changes are due to chance or potentially a result of the course, we examined the scores using a dependent samples t-test and tested for treatment effect size using Cohen's d (Table 6).

The results from the quantitative analysis, as illustrated in Table 6, indicate there is statistical significance with large effect size in both the overall self-efficacy and the personal science teaching efficacy (PSTE) subscale. No statistical significance and a small effect size was observed with science teaching outcome expectancy (STOE). This finding indicates

Table 5 Descriptive statistics for STEBI-B

Construct	N	Pretest Mean (SD)	Posttest Mean (SD)	Standard Error of Measurement	
				Pretest	Posttest
Overall STEBI	22	3.50 (0.392)	3.91 (0.233)	0.0835	0.0496
STOE	22	3.61 (0.505)	3.75 (0.345)	0.108	0.0735
PSTE	22	3.43 (0.581)	4.03 (0.322)	0.124	0.0688

preservice teachers' general confidence had improved but remain mostly unchanged for student outcomes based on their teaching.

Qualitative findings As we began code our data, we identified trends that resulted in four category codes, which are defined in Table 7.

After placing each qualitative response into one of these four categories, further descriptive codes that were more unique in nature were assigned to help us make sense of specific influences on the preservice teacher's self-efficacy. These codes include course-specific practices (NOS, 5E, SSI) and elementary classroom-based experiences (student engagement, hands-on learning). After identifying these descriptive codes, we coded the responses as they connected to Bandura's four sources of self-efficacy (vicarious experiences, mastery experiences, social persuasion, affective responses) to determine the source

Table 6 Comparison of pre and post intervention scores on the STEBI-B using a paired t-test

Construct	Mean Change (Standard Deviation)	t	p-value	Effect size (Cohen's d)
Overall STEBI	.401 (.389)	4.932	$p < .001$	1.48 (large)
STOE	.136 (.429)	1.490	.151	0.32 (small)
PSTE	.600 (.691)	4.074	$p < .001$	1.28 (large)

Table 7 Category codes with definitions

Code	Definition
Experiencing pedagogy as a student	In the pre-course question responses, this code was assigned to past experiences of how science was taught during preservice teachers' K-12 schooling. In the post-course question, however, the definition of those code shifted to focus on past experiences of how science was taught during the methods course when the preservice teachers were acting as students to learn the pedagogy
Content knowledge	The preservice teacher's understanding of science content
Interest/passion	Enjoying science and/or wanting to share that joy with students
Enacting pedagogy as a teacher	Experiences of the preservice teacher facilitating science in their elementary practicum classroom

of influences on self-efficacy. In addition to assigning the codes, we also noted whether the response expressed positive or negative feelings toward teaching elementary science.

While analyzing the qualitative data, there were times where we assigned multiple categorical codes. For instance, in the response below, preservice teacher #6 explains that while they feel more confident in their abilities to teach science, they recognize the need to develop a deeper understanding of content.

> I feel that I will be confident in my implementation of engaging science lessons. I do need to work on my content knowledge, however. This class provided me with many tools and resources to help me be successful (formative assessments, SSI activities, etc.).

This example was coded as vicarious experiences being the source of positive feelings toward teaching science that were developed as the preservice teacher engaged with pedagogy as a student, as well as negative feelings toward content knowledge.

In addition to the categorical codes, we used descriptive codes to identify how the methods course, and specifically SSI, was influential in the preservice teachers' beliefs about their science teaching self-efficacy. The quantities for the most frequent influences are presented in Table 8.

Table 8 illustrates SSI as the most frequently mentioned strategies the preservice teachers in the course identified as influential to their confidence toward teaching science in elementary school. There were often more than one strategy mentioned in each response, which accounts for the difference in values between the number of preservice teachers in the course and the number of times a strategy is mentioned.

In addition to providing overviews of trends in the qualitative responses, we would also like to illustrate how the qualitative responses highlight growth in preservice teachers' science teaching self-efficacy. In Table 9 we provide evidence for how SSI was explicitly identified as influential for some of these preservice teachers.

Discussion

Due to the limited instruction focused on SSI in the elementary context, it is a safe assumption that elementary science methods courses do not typically include SSI. With research question one, our goal was to identify how elementary preservice teachers' science teaching self-efficacy changed when they did have the opportunity to engage with SSI during their methods course. Due to the existing perception that SSI is too complex for elementary

Table 8 Most frequent positive post-course influences on science teaching self-efficacy

Descriptive code	Number of explicit mentions
Socioscientific issues (SSI)	7
Hands-on activities (general)	6
5E inquiry model	4
Nature of science (NOS)	2
Formative assessments	2
Engagement	2

Table 9 Evidence of improved self-efficacy due to SSI

Preservice teacher ID	Pre-intervention response	Post-intervention response	Researcher interpretation
6	Although towards the end of my academic career I did not enjoy science, I still think it is very important to teach it to young students. Since I have had a few teachers that made me disinterested in science, I want to be able to inspire my students and get them engaged and excited to learn. At a young age, I know lots of children might not have had opportunities to explore their likes, dislikes, and passions, and as a future educator, I want to be able to expose my students to all subjects, regardless of how I feel about those subjects	I feel that I will be confident in my implementation of engaging science lessons. I do need to work on my content knowledge, however. This class provided me with many tools and resources to help me be successful (formative assessments, SSI activities, etc.)	The preservice teacher began the course with a positive outlook on teaching science (affective response) but mentions negative past experiences (mastery learning experiences) with science influencing her overall feelings. After participating in the SSI-focused course, she alludes to new, positive mastery learning experiences and vicarious experiences as improving her overall confidence with teaching science. Additionally, she references newly learned pedagogical strategies as influencing her confidence
11	I am nervous about teaching science in elementary school. I am scared I won't convey passion for the subject and therefore my students won't care about the subject	I am confident in instruction through 5e's and SSI. I really like the 5e's and I feel I will be using that template for many lessons, not just science. It has made me feel more comfortable teaching concepts I don't fully understand	While the preservice teacher initially felt nervous about teaching elementary science, engaging with SSI and the 5E model during the course helped this preservice teacher feel more confident in their abilities to facilitate science instruction. This new level of comfort is indicative of how providing vicarious experiences through modeling application of the 5E inquiry-based model through SSI can improve science teaching self-efficacy

instruction (Kılınç et al. 2013) we wondered if incorporating it into the methods course would deter preservice teachers from wanting to teach science, thus negatively influencing their self-efficacy. Our quantitative data, however, illustrates positive changes in overall science teaching self-efficacy and PSTE, which were statically significant with a large effect size. While it is common for participation in science methods courses to result in an increase in self-efficacy (e.g. Webb and LoFaro 2020), our quantitative results illustrate this is true for courses that engage preservice teachers with SSI.

Additionally, the quantitative data did not show statistical significance with STOE. It is not uncommon for studies focused on improving science teaching self-efficacy to not see a significant improvement in the scores associated with STOE (e.g. Kırık 2013). Research that emphasizes field-experiences, however, have shown a tendency to show slight increases in STOE (e.g. Flores 2015). Our quantitative results regarding the lack of significance with STOE is somewhat expected since we were not focused on field-based experiences, but more on how the engagement with SSI in the methods course influenced general self-efficacy.

As we coded our qualitative data, we found the shift of sources of self-efficacy as well as the influences to be noteworthy. Specifically, we noted how the pre-course findings illustrate three preservice teachers mentioning content knowledge to support their negative self-efficacy, while the post-course qualitative findings had five students mention content knowledge as a source of low self-efficacy. Content knowledge is a common reason mentioned for low confidence in science teaching (Menon and Sadler 2016), but this increase was interesting. We believe the preservice teachers may not have been aware of their lack of content knowledge until they began to engage with content in the course, which is why we saw more preservice teachers acknowledge science content as an influence for low self-efficacy. Also noteworthy was the shift in sources of self-efficacy. The pre-course question illustrated preservice teachers drawing from their experiences as students in K-12 environment as influential to their self-efficacy, but at the end of the course, their developed understanding of pedagogy through vicarious experiences in the course was the main source of positive self-efficacy. This demonstrates how valuable modeling lessons for preservice teachers can be, especially when it is unclear of what they are observing while in their field experiences.

As we analyzed our data concerning influences on positive self-efficacy, we noted that SSI was the most frequently mentioned positive influence, followed by general hands-on activities and the 5E instructional model. This is optimistic for SSI since the design of the course was not to favor one pedagogical approach over the other, but to provide a variety of instructional practices throughout the semester that may be used in future science instruction. The findings that illustrate SSI as most influential provides evidence for how impactful this approach to science teaching may be for elementary preservice teachers and their future students.

Implications

The qualitative data in our study revealed that despite SSI's history of improving science content knowledge with other populations (such as with high school students in Sadler, Romine, & Topcu, 2016), simply modeling SSI lessons during a methods course had more pedagogical than content knowledge influences on confidence with science teaching. Since a lack of science content knowledge is a common stimulus for low science teaching self-efficacy (Menon and Sadler 2016), there is room for improvement in how SSI is presented during science methods courses. If future studies have aims to utilize SSI for the purpose of improving content knowledge, science teacher educators should explore how placing explicit emphasis on the content associated with the SSI influences confidence regarding science content knowledge.

In addition to a content knowledge emphasis, we would also like to note the need for experiences teaching science that includes SSI and other influential pedagogical approaches as identified by these preservice teachers. In the post-course question, one preservice teacher called attention to the need for practice enacting science before s/he felt more confident with their abilities to teach science in their own classroom. This finding has implications for future teacher educators who wish to improve science teaching self-efficacy through SSI and identifies a potential need to provide opportunities for teaching SSI. While microteaching opportunities have been shown to improve self-efficacy (Cinici 2017) and may be a practicable option for SSI in methods courses, we argue for authentic teaching of SSI in the elementary context to provide opportunities to gain mastery experiences with the pedagogical approach.

Conclusion

The present study found that having vicarious experiences with SSI during an elementary science methods course positively influenced preservice teachers' general science teaching self-efficacy. Some evidence presented in the findings, however, reveals identifying efficacious influences through SSI is only the first step to improving elementary science teaching, with the next step in this process involving opportunities to develop content knowledge and engage in mastery experiences facilitating SSI. With the existence of SSI being limited in elementary classrooms, preservice teachers are often not exposed to this approach. Providing opportunities to engage with SSI during methods courses will not only improve self-efficacy but will also introduce a rigorous approach to science instruction preservice teachers would otherwise miss. We believe this investigation provides some guidance in how science methods courses for future elementary teachers can be leveraged to support confidence with science instruction, pedagogical advances in general, and SSI-based instruction in particular.

References

Akyol, G., Tekkaya, C., Sungur, S., & Traynor, A. (2012). Modeling the interrelationships among pre-service science teachers' understanding and acceptance of evolution, their views on nature of science and self-efficacy beliefs regarding teaching evolution. *Journal of Science Teacher Education, 23*(8), 937–957. https://doi.org/10.1007/s10972-012-9296-x.

Appleton, K., & Kindt, I. (1999). Why teach primary science? Influences on beginning teachers' practices. *International Journal of Science Education, 21*(2), 155–168. https://doi.org/10.1080/095006999290769.

Avery, L. M., & Meyer, D. Z. (2012). Teaching science as science is practiced: Opportunities and limits for enhancing preservice elementary teachers' self-efficacy for science and science teaching. *School Science and Mathematics, 112*(7), 395–409. https://doi.org/10.1111/j.1949-8594.2012.00159.x.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84,* 191–215.
Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4), 71–81. New York: Academic Press.
Bleicher, R. E. (2004). Revisiting the STEBI-B: Measuring self-efficacy in preservice elementary teachers. *School Science and Mathematics, 104*(8), 383–391. https://doi.org/10.1111/j.1949-8594.2004.tb18004.x.
Cervato, C., & Kerton, C. (2017). Improving the Science Teaching Self-Efficacy of Preservice Elementary Teachers: A Multiyear Study of a Hybrid Geoscience Course. *Journal of College Science Teaching*, *47*(2). https://doi.org/10.2505/4/jcst17_047_02_83.
Cinici, A. (2017). Pre-service Teachers' Science Teaching Self-efficacy Beliefs: The Influence of a Collaborative Peer Microteaching Program. *Mentoring & Tutoring: Partnership in Learning, 24*(3), 228–249. https://doi.org/10.1080/13611267.2016.1222812.
Coladarci, T., Cobb, C. D., Minium, E. W., & Clarke, R. C. (2014). *Fundamentals of statistical reasoning in education* (Fourth Edition). Hoboken, NJ: John Wiley & Sons.
Enochs, L., & Riggs, I. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90,* 694–706.
Flores, I. M. (2015). Developing Preservice Teachers' Self-Efficacy through Field-Based Science Teaching Practice with Elementary Students. *Research in Higher Education Journal*, *27,* 1–19.
Forbes, C. T., & Davis, E. A. (2008). The development of preservice elementary teachers' curricular role identity for science teaching. *Science Education, 92*(5), 909–940. https://doi.org/10.1002/sce.20265.
Greene, J. C. (2007). *Mixed methods in social inquiry* (Vol. 9). San Francisco, CA: John Wiley & Sons.
Gunning, A. M., & Mensah, F. M. (2011). Preservice elementary teachers' development of self-efficacy and confidence to teach science: A case study. *Journal of Science Teacher Education, 22*(2), 171–185. https://doi.org/10.1007/s10972-010-9198-8.
Hesse-Biber, S. N. (2010). *Mixed methods research: Merging theory with practice*. New York: Guilford Press.
Hestness, E., McGinnis, J. R., Riedinger, K., & Marbach-Ad, G. (2011). A Study of Teacher Candidates' Experiences Investigating Global Climate Change Within an Elementary Science Methods Course. *Journal of Science Teacher Education, 22,* 351–369. https://doi.org/10.1007/s10972-011-9234-3.
Ilhan, N., Yilmaz, Z. A., & Dede, H. (2015). Attitudes of pre-service science teachers towards educational research and their science teaching efficacy beliefs in Turkey. *Journal of Baltic Science Education, 14*(2).
Kazempour, M., & Sadler, T. D. (2015). Pre-service teachers' science beliefs, attitudes, and self-efficacy: A multi-case study. *Teaching Education, 26*(3), 247–271. https://doi.org/10.1080/10476210.2014.996743.
Kılınç, A., Kartal, T., Eroğlu, B., Demiral, Ü., Afacan, Ö., Polat, D., et al. (2013). Preservice science teachers' efficacy regarding a socioscientific issue: A belief system approach. *Research in Science Education, 43,* 2455–2475. https://doi.org/10.1007/s11165-013-9368-8.
Kırık, Ö. T. (2013). Science teaching efficacy of preservice elementary teachers: examination of the multiple factors reported as influential. *Research in Science Education, 43*(6), 2497–2515. https://doi.org/10.1007/s11165-013-9357-y.
Kinskey, M. (2018). Using action research to improve science teaching self-efficacy. *International Journal of Science Education, 40*(15), 1795–1811. https://doi.org/10.1080/09500693.2018.1502898.
Menon, D., & Sadler, T. (2016). Preservice elementary teachers' science self-efficacy beliefs and science content knowledge. *Journal of Science Teacher Education, 27,* 649–673. https://doi.org/10.1007/s10972-016-9479-y.
Menon, D. (2020). Influence of the sources of science teaching self-efficacy in preservice elementary teachers' identity development. *Journal of Science Teacher Education*, 1-22. https://doi.org/10.1080/1046560X.2020.1718863.
National Research Council [NRC]. (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. Washington DC: National Academies Press.
Palmer, D., Dixon, J., & Archer, J. (2017). Using situational interest to enhance individual interest and science-related behaviours. *Research in Science Education, 47*(4), 731–753. https://doi.org/10.1007/s11165-016-9526-x.
Pitiporntapin, S., Yutakom, N., & Sadler, T. D. (2016, December). Thai pre-service science teachers' struggles in using Socio-scientific Issues (SSIs) during practicum. In *Asia-Pacific Forum on Science Learning & Teaching 17*(2), 1–20.

Ramey-Gassert, L., & Shroyer, M. G. (1992). Enhancing science teaching self-efficacy in preservice elementary teachers. *Journal of Elementary Science Education, 4*(1), 26–34.

Ramey-Gassert, L., Shroyer, M. G., & Staver, J. R. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level teachers. *Science Education, 80*(3), 283–315. https://doi.org/10.1002/(SICI)1098-237X(199606)80:3<283::AID-SCE2>3.0.CO;2-A.

Rundgren, C. J., Eriksson, M., & Rundgren, S. N. C. (2016). Investigating the intertwinement of knowledge, value and experience of upper secondary students' argumentation concerning socioscientific issues. *Science & Education, 25,* 1049–1071. https://doi.org/10.1007/s11191-016-9859-x.

Sadler, T. D. (2011). Socio-scientific issues-based education: What we know about science education in the context of SSI. In *Socio-scientific Issues in the Classroom* (pp. 355–369). New York: Springer

Sadler, T. D., Romine, W. L., & Topçu, M. S. (2016). Learning science content through socio-scientific issues-based instruction: A multi-level assessment study. *International Journal of Science Education, 38*(10), 1622–1635. https://doi.org/10.1080/09500693.2016.1204481.

Saunders, K. J., & Rennie, L. J. (2013). A pedagogical model for ethical inquiry into socioscientific issues in science. *Research in Science Education, 43,* 253–274. https://doi.org/10.1007/s11165-011-9248-z.

Trauth-Nare, A. (2015). Influence of an intensive, field-based life science course on preservice teachers' self-efficacy for environmental science teaching. *Journal of Science Teacher Education, 26*(5), 497–519. https://doi.org/10.1007/s10972-015-9434-3.

Usher, E. L., Ford, C. J., Li, C. R., & Weidner, B. L. (2019). Sources of math and science self-efficacy in rural Appalachia: A convergent mixed methods study. *Contemporary Educational Psychology, 57,* 32–53. https://doi.org/10.1016/j.cedpsych.2018.10.003.

Walker, K. A., & Zeidler, D. L. (2007). Promoting discourse about SSI through scaffolded inquiry. *International Journal of Science Education, 29*(11), 1387–1410. https://doi.org/10.1080/09500690601068095.

Watters, J. J., & Ginns, I. S. (2000). Developing motivation to teach elementary science: Effect of collaborative and authentic learning practices in preservice education. *Journal of Science Teacher Education, 11*(4), 301–321. https://doi.org/10.1023/A:1009429131064.

Webb, D. L., & LoFaro, K. P. (2020). Sources of engineering teaching self-efficacy in a STEAM methods course for elementary preservice teachers. *School Science and Mathematics, 120*(4), 209–219. https://doi-org.ezproxy.lib.usf.edu/10.1111/ssm.12403.

Yoon, S., Pedretti, E., Pedretti, L., Hewitt, J., Perris, K., & Van Oostveen, R. (2006). Exploring the use of cases and case methods in influencing elementary preservice science teachers' self-efficacy beliefs. *Journal of Science Teacher Education, 17*(1), 15–35. https://doi.org/10.1007/s10972-005-9005-0.

Zeidler, D. L. (Ed.). (2003). *The role of moral reasoning on socioscientific issues and discourse in science education* (Vol. 19). Berlin: Springer Science & Business Media.

Zeidler, D. (2014). Socioscientific Issues as a curriculum emphasis: Theory, research and practice. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education (Vol. 2)*. New York: Routledge.

Zeidler, D. L., & Kahn, S. (2014). *It's debatable: Using socioscientific issues to develop scientific literacy, K-12*. Arlington: National Science Teachers Association Press.