ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 28, NO. 1, 76-92

ICRSME
International Consortium for Research in
Science & Mathematics Education

Effects of Informal versus School-Based Field Experience on Elementary Preservice Teachers' Self-Efficacy for Teaching Science

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ABSTRACT

Prior to the fall semester of 2017, the elementary preservice teachers who were enrolled in a science methods course engaged in a variety of field experiences across different settings, mostly informal. Beginning in the fall semester of 2017, students enrolled in this science methods course completed their field experience in formalized classroom settings. Most students were placed at the site of a partnership school, a K-8 building in the local urban school district where an automated greenhouse was built. At the outset, the original study aimed to compare the self-efficacy for science teaching of the elementary education preservice teachers pre- and post-greenhouse implementation. However, the construction of the greenhouse was delayed and thus accidentally created a third cohort of students in addition to pre- and post-greenhouse. This third cohort of students were placed in a K-8 school setting but did not have access to the greenhouse. This paper compares the first two cohorts of preservice teachers, those who completed informal field experiences, and those who completed school-based field experiences without the utilization of the greenhouse.

Keywords: science education, preservice teachers, elementary science, field experience

Introduction

Science, technology, engineering, and math (STEM) fields are an ever-growing part of today's workforce (Casey, 2012). However, STEM education in K-12 schools has been sparse (National Research Council, 2012). To increase the number of college graduates in the STEM fields, K-12 schools must engage students in STEM from a young age. Unfortunately, this does not happen to the extent necessary, particularly in elementary schools. This is largely due to the fact that many elementary teachers have low self-efficacy for teaching science.

Ashton and Webb (1986) built on Bandura's (1977) idea of self-efficacy by adding two types of self-efficacy for teaching that then were expanded to content specific areas. In science, these two types are personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). PSTE is the teachers' belief that they can effectively teach science. STOE is the idea that effective teaching will positively impact K-12 student learning (Bursal, 2012). Prior research has determined that a large percentage of elementary teachers (both preservice and inservice) have low science teaching self-efficacy of both types (Bursal, 2012). This low self-efficacy has been linked to heightened anxiety about, and negative attitudes towards, science (Bursal, 2012; Ramey-Gassert & Shroyer, 1992). High levels of science anxiety and feelings of low self-efficacy cause elementary teachers to avoid teaching science in K-8 classrooms (Bursal, 2012). In today's fast-moving world of STEM innovation, avoidance of science is detrimental to elementary student populations.

In 2015, an Engineering faculty member at Pennsylvania Collegiate Institute (PCI, pseudonym used) approached a faculty member in the Education department about a potential collaboration. PCI is a mid-sized liberal arts college in the south central section of the state. The proposal was that the Engineering students would design and build an automated greenhouse at a local elementary school that the Education students (preservice teachers) would then utilize to implement science lessons.

Dorchester Elementary (pseudonym used) is one of eight elementary schools in the local, urban school district that borders PCI. The majority of the students who attend the school are of African American or Hispanic descent, many are English language learners, and nearly all qualify for free/reduced lunch. The district where Dorchester resides often ranks as one of the lowest in the state. Dorchester was chosen as the specific school to place the greenhouse because of its 10,000 square-foot garden space enclosed within an interior courtyard.

The greenhouse project had several goals, and while the details of those goals are beyond the scope of this work (Forsyth & Hesson, 2017) may be consulted for more information. Yet, unfortunately, the greenhouse build ran into a multitude of challenges, all of which are described in Meah et al., 2021. The initial research study aimed to compare the self-efficacy of two cohorts of elementary preservice teachers: pre- and post-greenhouse utilization. Due to the challenges encountered in building the greenhouse structure (and an unforeseen global pandemic), a third cohort of preservice teachers was accidentally created. While the creation of the greenhouse was the impetus for this project, this paper will focus on the comparison of preservice teachers who completed informal field experiences to those who completed school-based field experiences.

Research has found that there are ways to increase self-efficacy for teaching science among elementary science preservice teachers. However, it is important to note that science anxiety, attitudes, and self-efficacy are all linked. Increasing positive attitudes toward science and/or reducing anxiety around science content have been shown to increase self-efficacy for teaching science (Ramey-Gassert & Shroyer, 1992). Attempts to grow positive attitudes, increase self-efficacy, and reduce anxiety should occur in teacher preparation courses. Science methods courses that utilize hands-on inquiry approaches and firsthand teaching experiences appear to be the best at increasing preservice teacher self-efficacy (Bursal, 2012). Positive student teaching experiences implementing science lessons have also been shown to reduce anxiety around teaching science (West, 1993). Moreover, prior research supports the idea that providing preservice teachers with real-world contexts for teaching science increases their self-efficacy (Kazempour, 2018; Novak & Wisdom, 2018; Valente et al., 2018; Yu & Bethel, 1991). Generally, previous research demonstrates that teacher educators need to use methods courses to help preservice teachers reduce anxiety and develop positive attitudes toward science. This will lead to increased science teaching self-efficacy.

Research Study Questions

All elementary education (PK-4) majors at PCI must successfully complete a science methods course, ECH 330: Teaching Science at the Early Childhood Level. This course has a 20-hour field experience requirement. Prior to the fall semester of 2017, the preservice teachers enrolled in this course completed their field experience hours in a variety of settings, mostly engaging in informal science instruction. One component required students to attend a volunteer training for the nature center at a local state park and then assist a group of students on a field trip. A second component involved delivering a lesson designed by a national program. Some of these programs took place in classroom settings, some took place in after school settings, and some took place at the local branch of the county library. The field experience activities were haphazard and not consistent among preservice teachers, even in the same methods class. This group is labeled Cohort A (informal field experience).

The lead author inherited the ECH 330 course during the fall 2017 semester following a colleague's retirement. While the course continued to utilize a hands-on inquiry approach, the author added the component of an authentic classroom experience that did not exist before. After the fall 2017 semester, all preservice teachers enrolled in ECH 330 completed their field experience hours in formalized classroom settings. During these school-based field experiences, preservice teachers engaged in more typical field experience activities, such as working with students in small groups, connecting science to literature, and teaching at least one whole-group lesson. Preservice teachers were required to spend at least six hours in the field every week for 12 weeks. The details of how the classroom placements were made in the subsequent four semesters are described in the methods section below. This group is labeled Cohort B (formal field experience).

According to prior research, the utilization of the garden at Dorchester, in conjunction with hands-on inquiry-based pedagogies in the science methods course and formalized, authentic field experiences in K-4 classrooms, should result in higher PSTE and STOE for preservice elementary teachers. Therefore, this paper asks three questions:

1. Does the type of field experience placement, formal or informal, have an impact on overall self-efficacy for teaching science among elementary preservice teachers?
2. Does the type of field experience placement, formal or informal, have an impact on self-efficacy for teaching science among elementary preservice teachers in two sub-categories: PSTE and STOE?
3. What role does the type of field experience placement, formal or informal, have on elementary preservice teachers' perceptions about their self-efficacy for teaching science?

Methods

All participants were preservice teachers at PCI. Starting in the fall 2017 semester, preservice teachers enrolled in ECH 330 completed their field experience hours in classroom settings. Under the assumption that the greenhouse would be operational by fall 2017, the education department began placing students in ECH 330 at the partnership school, Dorchester Elementary, during this time. If preservice teachers were not placed at Dorchester, every effort was made to place them in the same urban district. However, not all students enrolled in the course were placed at Dorchester, nor in the urban district, and there were a number of reasons for this. In the spring semester of 2018, there was a miscommunication between the Field Services Division at PCI and the local urban district when it came to placements. At times, Dorchester could not support all of students enrolled in ECH 330. Alternatively, some elementary preservice teachers arranged to transition from their field experience directly into student teaching, typically in more suburban districts. Lastly, sometimes the preservice teachers were co-enrolled in courses that required field experience that was difficult to complete at Dorchester and so were given different placements. Nearly all students completed their field experience hours in a PK-4th grade classroom. In certain cases, some students were placed in a 5/6th grade classroom, and most of these students were obtaining a dual elementary/special education certification. The special education certification in this state certifies students up to 8th grade, so most preservice teachers were within their certification band. In the fall of 2017, one student enrolled in ECH 330 was earning a middle level certification (grades 4-8), and so she was placed in a 5/6th grade classroom. Table 1 shows the breakdown of student placements by semester.

Table 1

Student Field Experience Placements by Semester

Semester	Enrolled in ECH 330	Dorchester	Urban, but not Dorchester	Outside Urban District	Above 4th grade (5/6)
Fall 2017	26	23	2	1	3 (2 dual SPED, 1 MLE)
Spring 2018	26	2	4	20	2 (both dual SPED)
Fall 2018	17	12	2	3	2 (1 dual SPED)
Spring 2019	12	7	5	0	1 (dual SPED)

Beginning in the fall semester of 2016, students enrolled in ECH 330 were asked to participate in the current research study. At the start of each semester, students who volunteered to participate were asked to sign an informed consent form and complete the Science Teaching Efficacy Belief Instrument (STEBI-B), a measure of self-efficacy for teaching science in preservice elementary teachers (Bleicher, 2004). Initially designed by Enochs and Riggs (1990), Bleicher (2004) edited the instrument to revise or remove items that were found non-reliable, thus making the overall instrument more valid for use with preservice teachers. A copy of the STEBI-B can be found in the methods supplement. The same participants were asked to complete the STEBI-B at the end of the semester as well. The STEBI-B was administered by the lead author every semester. Students were instructed to use the same alphanumeric code for both the pre- and post-test so that their data would be anonymous but still trackable for comparison. Data was compared using the SPSS Statistics program.

Additionally, a subset of participants each semester were invited to join a focus group to discuss their field experience placements. Initial focus groups were conducted by the lead author on this paper. Later focus groups were conducted by a student research assistant who was unaffiliated with the class, since the lead author was the professor for ECH 330. The questions asked during the focus group are available as supplementary material accompanying the online article. Focus groups were recorded and transcribed, with most transcriptions completed through a service, but two were transcribed by a student research assistant. There were two supplementary pieces of qualitative data collected as well. In the fall 2017 semester, students were asked to volunteer to submit responses to a set of questions about their experience at urban placements. Fourteen students opted to complete this assignment. This list of questions is available as supplementary material accompanying the online article. In the spring semester of 2019, some students made mention of their experiences at Dorchester as a part of an unrelated assignment. These students granted permission to use their comments as part of this study. Qualitative data was coded for patterns by the lead author on this paper. Table 2 shows the participants who completed the STEBI-B and joined the focus group by semester.

Table 2

STEBI-B and Focus Group Participants by Semester

Semester	STEBI-B *n*	Focus Group *n*
Fall 2016 – Cohort A	24	6
Spring 2017 – Cohort A	15	4
Fall 2017 – Cohort B	26	6
Spring 2018 – Cohort B	24	5
Fall 2018 – Cohort B	9	8
Spring 2019 – Cohort B	12	5
TOTAL Cohort A	**39**	**10**
TOTAL Cohort B	**71**	**24**
OVERALL TOTAL	**110**	**34**

Cohort A includes those students who completed their field experience hours for ECH 330 at informal settings. Cohort B includes those students who completed their field experience hours for ECH 330 in formalized classroom settings.

Results

Impact on Overall Self-Efficacy

The first question researchers sought to answer was: Does the type of field experience placement, formal or informal, have an impact on overall self-efficacy for teaching science among elementary preservice teachers? This question was addressed by comparing the difference in means of the pre- and post-STEBI-B results overall for Cohorts A and B. Descriptive data summarizing these results are displayed in Table 3.

Table 3

Average Difference in Overall Means for Cohorts A and B

Measure	n	Mean
Cohort A	39	0.229
Cohort B	71	0.402

An independent samples *t*-test was employed to determine the existence of a statistically significant difference between Cohort A and Cohort B STEBI-B scores. The null hypothesis for this independent samples *t*-test was that there was no difference in the mean STEBI-B scores of Cohort A and Cohort B. The independent samples *t*-test indicated a *p* value of 0.002. This value is below the $p = 0.05$ threshold indicating the null hypothesis was rejected. The results of the independent-sample *t*-test indicated that the mean scores for Cohorts A and B were significantly different, with Cohort B reporting higher self-efficacy for teaching science than Cohort A. Table 4 presents the results of this independent samples *t*-test.

Table 4

Independent-Sample t-test Comparing Overall Scores for Cohorts A and B

	df	MD	t	p
Cohorts A + B Overall Scores	108	-0.174	-3.215	0.002

Data collected from the beginning (pre) and end of course (post) administration of the STEBI-B were compared to answer research question one. Results for Cohorts A and B combined are displayed in Table 5. The null hypothesis for the paired sample *t*-test, employed to determine if there was a statistically significant difference between participants' self-efficacy for teaching science prior to completing ECH 330 (pre) and after completing ECH 330 (post), indicated that there was no difference between the mean scores for the pre and post-STEBI-B samples, either overall or on either subscale.

The paired samples *t*-test indicated a p value less than 0.00 on all three measures. These values are below the $p = 0.05$ threshold, indicating a rejection of the null hypothesis. The results of the paired samples *t*-test on all three measures demonstrated that post-STEBI-B scores were significantly higher than pre-STEBI-B scores. The results are illustrated in Table 6.

Table 5

Combined Pre- and Post-Course STEBI-B Overall and Subscale Results

Measure	n	Mean	SD
Overall Pre	110	3.673	0.291
Overall Post	110	4.014	0.345
PSTE Pre	110	3.804	0.332
PSTE Pre	110	4.260	0.367
STOE Pre	110	3.495	0.431
STOE Post	110	3.669	0.478

Table 6

Paired Sample t-test Comparison of Pre- and Post-Course Overall and Subscale Scores

Measure	df	Mean	SD	t	p
Overall Pre-Post	109	-0.341	0.282	-12.660	0.000
PSTE Pre-Post	109	-0.455	0.325	-14.684	0.000
STOE Pre-Post	109	-0.173	0.446	-4.076	0.000

Impact on Subcategories of Self-Efficacy (PSTE & STOE)

The second question researchers sought to answer was: Does the type of field experience placement, formal or informal, have an impact on self-efficacy for teaching science among elementary preservice teachers in two sub-categories: PSTE and STOE? This question was addressed by comparing the difference in means of the pre- and post-STEBI-B results for subsets of questions on the STEBI-B as defined by Bleicher (2004). PSTE was measured by questions 2, 3, 5, 6, 8, 12, 17, 19, 20, 21, 22, and 23. STOE was measured by questions 1, 4, 7, 9, 10, 11, 13, 14, 15, and 16. Descriptive data summarizing these results are displayed in Table 7.

Table 7

Average Difference in PSTE and STOE Means for Cohorts A and B

Measure	n	PSTE Mean	STOE Mean
Cohort A	39	0.318	0.087
Cohort B	71	0.531	0.221

An independent samples *t*-test was employed to determine the existence of a statistically significant difference between the Cohort A and Cohort B subscale scores. The null hypothesis for this independent samples *t*-test was that there was no difference in the mean subscale scores of Cohort A and Cohort B. For the PSTE subscale, the independent samples *t*-test indicated a p value of 0.001. This value is below the $p = 0.05$ threshold indicating the null hypothesis was rejected. The results of the independent-sample *t*-test indicated that the mean scores for Cohorts A and B were significantly different, with Cohort B reporting a higher personal science teaching efficacy belief than Cohort A. For the STOE subscale, the independent samples *t*-test indicated a p value of 0.133. This value is above the p = 0.05 threshold indicating the null hypothesis was accepted. The results of the independent-sample t-test indicated that the mean scores for Cohorts A and B were not significantly different on the subscale of science teaching outcome expectancy. Table 8 presents the results of this independent samples t-test.

Table 8

Independent-Sample t-test Comparing Subscale Scores for Cohorts A and B

	df	MD	t	p
PSTE	108	-0.213	-3.449	0.001
STOE	108	-0.134	-1.515	0.133

Data collected from the beginning (pre) and end of course (post) administration of the STEBI-B were compared to answer research question one. Disaggregated results for Cohorts A and B are displayed in Table 9.

Table 9

Disaggregated Pre- and Post-Course STEBI-B Overall and Subscale Results

	Cohort A			Cohort B		
Measure	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
Overall Pre	39	3.744	0.306	71	3.634	0.277
Overall Post	39	3.972	0.383	71	4.037	0.322
PSTE Pre	39	3.903	0.399	71	3.750	0.277
PSTE Pre	39	4.220	0.420	71	4.281	0.335
STOE Pre	39	3.538	0.458	71	3.472	0.417
STOE Post	39	3.625	0.536	71	3.693	0.445

The null hypothesis for the paired sample t-test, was employed to determine if there was a statistically significant difference between participants' self-efficacy for teaching science prior to completing ECH 330 (pre) and after completing ECH 330 (post). Results from this study indicated that there was no difference between the mean scores for the pre- and post-STEBI-B samples, either overall or on either subscale. For Cohort A, the paired samples t-test indicated a p value less than 0.00 on the overall score and the STOE subscale score. These values are below the p = 0.05 threshold, indicating a rejection of the null hypothesis. The results of the paired samples t-test on these two measures for Cohort A demonstrated that post-STEBI-B scores were significantly higher than pre-STEBI-B scores. For Cohort A's PSTE, the paired samples t-test indicated a p value of 0.344. This value is above the p = 0.05 threshold, indicating an acceptance of the null hypothesis. The pre-test PSTE subscale scores for Cohort A were not significantly different than post-test scores.

The paired samples t-test indicated a p value less than 0.00 on all three measures for Cohort B. These values are below the p = 0.05 threshold, indicating a rejection of the null hypothesis. The results of the paired samples t-test on all three measures for Cohort B demonstrated that post-STEBI-B scores were significantly higher than pre-STEBI-B scores. The results described above are illustrated in Table 10.

Table 10

Paired Sample t-test Comparison of Cohort Specific Pre and Post-course Overall and Subscale Scores

		Cohort A			
Measure	**df**	**Mean**	**SD**	**t**	**p**
Overall Pre-Post	38	-0.229	0.283	-5.041	0.000
PSTE Pre-Post	38	-0.318	0.348	-5.706	0.344
STOE Pre-Post	38	-0.086	0.561	-0.958	0.000
		Cohort B			
Measure	**df**	**Mean**	**SD**	**t**	**p**
Overall Pre-Post	70	-0.402	0.264	-12.842	0.000
PSTE Pre-Post	70	-0.531	0.288	-15.555	0.000
STOE Pre-Post	70	-0.221	0.363	-5.128	0.000

Impact on Perceptions of Self-Efficacy

Lastly, the researchers wanted to answer the question: What role does the type of field experience placement, formal or informal, have on elementary preservice teachers' perceptions about their self-efficacy for teaching science? This question was answered qualitatively with focus group interviews and student writing samples. Questions for the focus group and writing samples can be found in the Methods Supplement for this paper. Our student researcher and the lead author on this paper utilized open coding to find patterns in the data. These patterns are described below.

Students in Cohort A felt that the informal settings were beneficial to observe and work with students in a variety of settings but did not believe the informal settings assisted their transition into a classroom. As one student noted "Even though I felt like I could take my kids outside and do a lot of extension activities…I didn't feel like I had that classroom experience to help boost my confidence in teaching a classroom science lesson." Another student noted that she wished she had spent more time "in a classroom teaching science" as opposed to informal settings because "it's just not beneficial to what we're going to be doing in our future." She went on to explain that field trips are becoming less and less frequent in the classroom and the informal settings seemed to be a mismatch. A third student stated that although she may have had bad experiences in previous school-based placements, she "still had an understanding of what [she] need[ed] to do for the grade" she might be teaching and she knew what she should be "reaching towards." She didn't feel the informal placements offered much value at all. These students felt that the informal settings lacked a future-looking attitude.

The Cohort A students' perceived low-self efficacy for teaching science could be related to the fact that many reported not writing or delivering their own science lessons in a classroom. Even students who spent some of their field placement time in a K-4 classroom did not feel confident in their ability to teach science. Some schools taught science very infrequently and it was difficult for the preservice teachers to plan to be present during science instruction. One student felt she was "kinda left in the dark on how to write [her] science lesson and what was gonna work with the kids." Others felt semi-confident in their ability with the grade where they were placed, but not with different grades. According to one student "I don't really feel necessarily confident in teaching a third or fourth-grade science lesson….because I've never had to write one or implement one." There was one informal setting that was perceived to be the most beneficial – placements with Leap into Science. More commonly referred to as Leap, this nationwide program "integrates open-ended science activities with children's books for young children and their families" (Franklin Institute, 2018). Students applauded this program because they were able to teach a lesson on their own "from start to finish." Another student added "we had that whole hour just for us, the teachers didn't chime in at all." The common experience that contributed positively to self-efficacy for teaching science was time spent developing and implementing their own lessons.

Cohort A thought the hands-on modeling of science teaching by the course professor was valuable, but again felt unable to translate this into teaching science in an elementary classroom. Several mentioned their ability to incorporate children's literature into a lesson and demonstrate hands-on activities, but one student commented: "some of the activities weren't always as realistic as what they would be in a classroom setting." Another student stated: "I know what inquiry based science is but I don't know how to implement it into my classroom." A third student added

> But I think realistically as a teacher you are going to have curriculum that you need to follow… I just feel like the whole semester being about inquiry based science was one, redundant, and two, not completely realistic. I just felt like there could have been a better balance with, I don't know, just some real stuff (Personal communication, May 9, 2017).

Students were taught about the 5E instructional model but lamented the lack of connection to "actual standards". At least two students stated that they would have liked to see a "better balance" between the hands-on component, the 5E model, and the science standards.

Another factor that negatively affected the confidence of Cohort A students was a lack of science content review in the methods course. While they felt confident in teaching generally, several noted that their confidence in science was "knock[ed] down" because they did not feel like they "learned anything about concepts, only about the approach to the concepts." One admitted to picking the "easiest" topic she could "instead of challenging [herself]" when she taught a short lesson because she was so uncomfortable with science content. Another reported feeling "at a loss in way" because she did not perceive any connection between the hands-on activities and science content that would be taught in a K-4 classroom. One student who taught a lesson through Leap into Science stated

> I was in a third grade classroom and at the time that we were going in they were in a matter unit and it was embarrassing how little I knew … My thoughts were how do you teach those science concepts when you don't understand them. Sure you might be the greatest teacher and you might have really good openers and closers and use the 5E model but just because you know how doesn't mean you know the content enough so I definitely don't feel prepared. I feel like I know how to approach science, but I don't think I would be confident in the science concept at hand. I would have to do a lot of outside research before I felt comfortable teaching it to my students (Personal communication, May 9, 2017).

The perceived lack of personal content knowledge combined with the perceived failure of science content review in the methods course caused many Cohort A students to feel a lowered sense of self-efficacy for teaching science.

Students in Cohort B agreed with students in Cohort A on some aspects. Cohort B had a different professor than Cohort A, but Cohort B agreed that the hands-on modeling by their course professor was valuable. In addition to hands-on activities, Cohort B also mentioned modeling of other pedagogies like extended wait time, flexible assignments and due dates, and questioning techniques. Other pedagogies were rarely mentioned by Cohort A. Cohort B agreed that there was "not really a lot of science" being taught in schools. They mentioned a stronger emphasis on mathematics and reading, which echoed sentiments by students in Cohort A.

Comments from Cohort B differed from Cohort A in three specific ways that impacted Cohort B's collective self-efficacy for teaching science. First, they reported more practice in lesson planning. Second, they received more review of elementary science content. Lastly, they were able to build relationships with their host teachers in the field placement classrooms as they delivered lessons to K-8th grade students. Each of these will be described in more detail.

Cohort A rarely implemented formal lessons, but when they did, the lessons were scripted. On the other hand, students in Cohort B had to create at least three distinct science lessons using the 5E lesson plan format, and they had to deliver at least one of those lessons. One of the required lessons was designed to be shorter in scope so that all lessons could be shared with peers in the class. According to one student, it helped him better understand the 5E format.

> I thought that the simplicity of it and the fact that we only had to really come up with the lesson as opposed to making materials and stuff, helped me focus on the scope and sequence of the lesson itself and come to an understanding of why it's structured the way it's structured, and being able to watch that reflected through how you taught your lessons in your class was beneficial. Because it kinda helps you focus on, like I said, it helps you focus on the structure of the lesson, you get less caught up in how pretty your stuff looks, and more focused on the sequence of it and stuff, and how you're supposed to introduce the content, and how you're supposed to distribute materials (Personal communication, December 2018).

Other students shared this sentiment as well. Several students also commented on the fact that the lessons were shared so the "book of science lessons…formatted in the 5Es already [would be] useful as a resource for us in the future." Cohort B shared many positive comments about the 5E lesson planning format and how the professor in the methods class modeled it. Although it was new to the students, they reported that planning and implementing lessons in this way was a valuable exercise. As one student said, "I know it was new to me and probably to everyone else too, so actually implementing that helped out a lot in understanding it more." Several students conveyed that utilization of the 5E model made it easier to incorporate what the Next Generation Science Standards (NGSS) refers to as Science and Engineering Practices (National Research Council, 2012). Science and engineering practices are those skills that transcend a science classroom like asking questions, using models, communicating information, and interpreting data. Cohort B also commented on the assignment that required them to plan a 5E lesson that connected to a field trip. While students thought it was a difficult assignment, they thought it was useful to think about all the behind-the-scenes aspects that go into planning a successful field trip. According to one, "this [was] the only time we've been taught how to prepare for a field trip, and I just thought that was a good tool to have."

Unlike Cohort A, Cohort B believed they received a lot of content review in their methods course. The professor for the methods course often had students plan lessons in groups. Students stated, "once we shared out…we did get multiple ideas for the same science topic, but different ways that we could go about teaching it for different grade levels." Lesson planning around a specific topic served as a content refresher for many students and they were able to take the ideas they got from their peers into their field placement classroom. Furthermore, students in the second half of Cohort B were required to take a science content course that covered concepts specialized for K-8th grade preservice teachers. Students in the first half of Cohort B suggested that such a course would be a good idea and students in the second half agreed. One student stated: "I think the concepts course helped prepare me for teaching science, because a lot of stuff that we may have forgotten over the years were reviewed [there], so that helped me teach science better." A second student agreed, "some of us didn't have to take science concepts, so that put us at a slight disadvantage for some of our content teaching." Another connected her experience in the science concepts course to the methods course saying, "the science concepts course helped me get back the knowledge that I sort of lost from elementary science but then the teaching science course really helped us actually create those science lesson plans." One student even said, "I was the least amount of nervous teaching my science lessons as I ever felt teaching a lesson" and she attributed this confidence to activities that had been done in the methods course. The addition of the science concepts course and extra content review in the methods course contributed positively to self-efficacy for teaching science.

For Cohort B, the factor that appeared to have the biggest positive impact on self-efficacy for teaching science was the actual experience in a K-8th grade classroom. Students in Cohort B made statements as follows

> I was never good at science either growing up or like in school, but after having this positive experience and learning so much throughout the semester, just like thinking about teaching science in the future doesn't really make me nervous and I feel like I have an abundance, a plethora, of resources to use. … I feel prepared to teach it in the future. (Personal communication, Spring 2018).

Two students commented that they had initially been nervous about being placed in a fourth grade classroom but felt much more confident in their ability to teach science after successfully teaching a lesson in an upper-elementary classroom. Other students referenced Cohort A's placements in informal settings, stating that such placements "would be a good testament to how it is to teach science in the classroom" because informal settings are designed to be engaging. Therefore, teachers do not need to "go the extra mile to put out that engagement factor" nor do they have to worry about classroom management. Many students in Cohort B discussed the relationships they had built with their field placement host teachers over the course of the semester. Several discussed the level of feedback they received, with one student stating that the in-depth feedback from the host teacher reaffirmed that, "she was grading [her] honestly" and she "really knew that [the host teacher] cared." The positive experiences in the classroom, both delivering lessons and interacting with in-service host teachers, contributed to the higher levels of self-confidence among the preservice teachers in Cohort B.

Discussion

Bursal (2012) found that science methods courses that utilize hands-on inquiry increase teacher self-efficacy. Data from this study support this finding. Although taught by different professors, both Cohort A and Cohort B were enrolled in a science methods course that employed a hands-on, inquiry model of teaching. When data for both cohorts was combined, there was a highly significant increase in overall self-efficacy for teaching science. Data also show a highly significant increase on both subscales of the STEBI-B, PSTE, and STOE. Cohort B demonstrated significant growth overall and in both subscales between pre- and post-test scores. Although Cohort A showed an increase in overall self-efficacy and STOE, Cohort A did not show a significant difference in PSTE between pre- and post-tests. For Cohort A, it seems the course and its accompanying informal field experiences did not have an effect on the preservice teachers' belief that they could effectively teach science. Cohort B completed field experience in formal classroom settings, whereas Cohort A completed their field experience in informal science settings. The biggest difference between Cohort A and Cohort B was the type of field placement setting. Combining the qualitative data with the quantitative data, the formal classroom experience of Cohort B appears to have had the most significant impact on overall self-efficacy and both sub-scales. Several studies have found that providing preservice teachers with firsthand experiences and real-world contexts for teaching science reduces anxiety around teaching science and increases self-efficacy for teaching science (Bursal, 2012; Kazempour, 2018; Novak & Wisdom, 2018; Valente et al., 2018, West, 1993 Yu & Bethel, 1991). Data from this study support these findings.

While a combined analysis of cohorts showed an increase in self-efficacy for teaching science, there was a difference between the two cohorts when their STEBI-B scores were compared. On overall self-efficacy for teaching science, the data show that Cohort B reported higher self-efficacy than Cohort A. When subscale scores for Cohorts A and B were compared, Cohort B reported a higher PSTE than Cohort A. However, there was no statistical difference between Cohorts A and B on the STOE subscale. STOE is the idea that effective teaching positively impacts K-12 student learning. Although Cohort B felt they were better able to effectively teach science (as measured by the PSTE subscale and reinforced through qualitative data), neither cohort felt that they would positively affect student learning. Comments about STOE did not appear in any comments by participants in the focus groups. In future semesters, a targeted question to solicit perceptions on STOE will be added to focus group interviews.

The addition of the science concepts class increased knowledge content confidence, which in turn increased Cohort B's self-efficacy for teaching science. Field experience placement in a classroom setting had a positive impact on preservice teachers' belief that they could effectively teach science. This was true for all participants in Cohort B and those few students in Cohort A who were able to teach a classroom-based lesson. The extra practice of planning and delivering their own lessons to K-8th grade students in a formalized setting served to increase their confidence. The informal settings did not increase confidence for preservice teachers in the same way, partially because the lessons were standardized. The actions of "being a teacher" – researching the content, writing a coherent lesson, and then delivering that lesson – were perceived by the participants as the best preparation for science teaching, and thus positively impacted their perception about their self-efficacy for teaching science.

Future Research

At the outset of the project, the study aimed to compare the self-efficacy for science teaching of the elementary education preservice teachers pre- and post-greenhouse implementation. However, the construction of the greenhouse was delayed and thus accidentally created a third cohort of students in addition to pre- and post-greenhouse. This study compared those preservice teachers who completed their field experience hours for ECH 330 at informal settings (pre-greenhouse) to those who completed their field experience hours in a K-8th grade school setting, but without access to the greenhouse. The greenhouse construction and automation was completed in August of 2019. Data collection began in spring 2020, but no post-treatment data was collected because of the global pandemic. The pause in data collection continued in the fall 2020 and the entire 2021-2022 academic year. The final phase of this project will be underway beginning in fall 2022 now that preservice teachers enrolled in ECH 330 can utilize the greenhouse as intended. Future research will compare three cohorts of preservice teachers: those who completed informal field experiences, those who completed formal field experiences without use of the greenhouse, and those who completed formal field experiences with the use of the greenhouse. The addition of the greenhouse will further increase the hands-on inquiry experiences and real-world contexts for our preservice teachers. This should increase the self-efficacy for preservice teachers even more. The lead author intends to resume data collection in fall 2023 for at least four subsequent semesters. This additional data will be compared to data presented in this study. It is the hope that a comparison of the three phases of the education piece of this project will continue to show an increase in self-efficacy for teaching science among elementary preservice teachers.

The authors received no financial support for the research, authorship, and/or publication of this manuscript.

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Appendix A

STEBI-B Survey Instrument

(Enochs & Riggs, 1990, modified Bleicher, 2004)

5 = STRONGLY AGREE 4 = AGREE 3 = UNCERTAIN 2 = DISAGREE 1 = STRONGLY DISAGREE

		SA	A	UN	D	SD
1.	When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	5	4	3	2	1
2.	I will continually find better ways to teach science.	5	4	3	2	1
3.	Even if I try very hard, I will not teach science as well as I will most subjects.	5	4	3	2	1
4.	When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	5	4	3	2	1
5.	I know the steps necessary to teach science concepts effectively.	5	4	3	2	1
6.	I will not be very effective in monitoring science experiments.	5	4	3	2	1
7.	If students are underachieving in science, it is most likely due to ineffective science teaching.	5	4	3	2	1
8.	I will generally teach science ineffectively.	5	4	3	2	1
9.	The inadequacy of a student's science background can be overcome by good teaching.	5	4	3	2	1
10.	The low science achievement of students cannot generally be blamed on their teachers.	5	4	3	2	1
11.	When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	5	4	3	2	1
12.	I understand science concepts well enough to be effective in teaching elementary science.	5	4	3	2	1
13.	Increased effort in science teaching produces little change in students' science achievement.	5	4	3	2	1
14.	The teacher is generally responsible for the achievement of students in science.	5	4	3	2	1
15.	Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	5	4	3	2	1
16.	If parents comment that their child is showing more interest in science, it is probably due to the child's teacher.	5	4	3	2	1
17.	I will find it difficult to explain to students why science experiments work.	5	4	3	2	1
18.	I will typically be able to answer students' science questions.	5	4	3	2	1
19.	I wonder if I will have the necessary skills to teach science.	5	4	3	2	1
20.	Given a choice, I will not invite the principal to evaluate my science teaching.	5	4	3	2	1
21.	When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand.	5	4	3	2	1
22.	When teaching science, I will usually welcome student questions.	5	4	3	2	1
23.	I do not know what to do to turn students on to science.	5	4	3	2	1

Appendix B

Focus Group Questions

1. Thinking about your elementary science methods course, can you identify any specific class activities that were particularly influential on your ability to teach your science?
    a. *Follow up on what was influential about them.*
    b. *Could be positive or negative.*
2. Do you feel like you were adequately prepared to teach science content?
    a. Why or why not?
    b. What factors do you attribute to that?
    c. *Could be related to this course or science content taught outside of the Edu department.*
3. Focusing on your stage 3 field experience related to science, how do you think what you have learned will affect your classroom practice?
4. Which activities/placements in the field experience for teaching science did you find most useful?
5. Which activities/placements in the field experience for teaching science did you find least useful?
6. Do you have any additional comments or thoughts regarding the methods course or field experiences for teaching elementary science?

Appendix C

Fall 2017 Voluntary Questions

1. How much prior exposure did you have interacting with populations like the ones at Goode? (Low SES, high poverty, ELL)
2. How much of that prior exposure was working in a school setting?
3. What were your feelings about working at Goode at the beginning of the semester? (positive, negative, indifferent)
4. How have your feelings about working with urban populations changed throughout the semester?
5. What did you learn about urban populations by working with Goode students?

Appendix D

Spring 2019 Final Reflections

In this general assignment for all students enrolled in the class, students were asked to reflect on their experiences at their field placement. The prompt is included below. Students were not explicitly asked to discuss their work with students in urban settings, but some chose to do so. I curated some of their responses to include in the qualitative data.

Description

You will observe several science and non-science lessons taught by your cooperating teacher(s) throughout your semester. At the end of the semester, you will write a 1-2 page reflection (double-spaced) of what you observed. Some questions to consider:

- In what ways did the teacher incorporate science? How often?
- What did the teacher do well?
- What would you have done differently?
- What did you have questions about?
- Did the students understand the material? How do you know?
- How did the teacher exemplify (or not) what has been learned in this course?
- Which best practices did the teacher implement?
- How did the teacher implement Next Generation Science Standards?