Addressing the Gap of Informal Science Field Experiences in Science Methods Courses

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Preservice teachers in science education courses do not generally experience informal, authentic science education practices in their fieldwork. This study used the Scholarship of Teaching and Learning to frame a study that integrated informal science teaching experiences with a university teacher education science methods course. The results showed improvement in participant preservice teachers' ability to teach science content, their self-confidence in teaching science, and their ability to connect what they learned in their methods course in a real-life setting.

INTRODUCTION

In many science methods classes taken by preservice teachers, instructors include assignments that attempt to connect the university classroom to the real world of teaching, yet the activities are generally not authentic teaching experiences. In the methods course described here, the assignment previous to this study that addressed informal science education was an artificial experience. It consisted of an online search of a science-related location (i.e., museum, nature center) and the development of a lesson plan to fit the local chosen. Course evaluations indicated students found this to be "busy work" and of no benefit to their future classrooms. These responses were the impetus for developing a new assignment in an effort to provide class participants in a real teaching experience in an informal science learning setting. The research presented here discusses the development of this new authentic assignment, and its effect on the preservice teachers' understanding of the teaching of science and the value of informal science experiences.

Study Description

This study took place in a small mid-western city and involved a partnership with a local children's museum, 46 third-grade classes, and preservice science teachers (n=35) over a two-semester period. Thirteen of the preservice teachers in the fall 2018 cohort (Cohort 1) and 11 in the fall 2019 cohort (Cohort 2) were also concurrently enrolled in Novice Teaching, a 100-hour field course taken prior to student teaching. Using the Scholarship of Teaching and Learning (SoTL) framework to integrate informal science education in the science methods courses, the participants were asked to create meaningful inquiry-based activities in energy education, present an inquiry lesson during the third-grader's museum field trips, reflect upon their experience, and revise their lesson and teaching strategies for future implementation.

LITERATURE REVIEW

Need for Preservice Science Teacher Preparation Real-World Connections

While most teacher education programs include various field experiences, preservice teachers (PTs) in science education programs often lack experience with informal, authentic science education practices in the field (Jung & Tonso, 2006; Avraamidou, 2017; Douglass & Verma, 2022). Despite calls for reform in science teacher preparation more than two decades ago (AAAS, 1998; National Research Council, 2002) and the current need for highly prepared teachers in science (García & Weiss, 2019), teachers often report feeling inadequately prepared and apprehensive about teaching science (Catalano et al., 2019). Menon and Sadler (2017) suggest the inadequacy could be a product of a disconnect between inquiry learning promoted in methods courses and lecture-based instruction many PTs observe in their placement classrooms. Furthermore, quality teacher education program should include frequent opportunity for practice, graduated responsibility, and structured opportunities. (Darling-Hammond & Oakes 2021; Ronfeldt, 2021). These long-standing issues indicate the continued need to reform science methods courses in science teacher preparation programs.

Scholarship of Teaching and Learning (SoTL)

Using the Scholarship of Teaching and Learning as a research methodology has evolved from a practice-centered inquiry (Boyer, 1990), collaboration and integration (Stefani, 2011) and improving student learning through studying and developing authentic learning skills and practices (Hutchins, Huber & Ciccone, 2011), to studying reflective practices and implementing contemplative pedagogies (Franzese & Felten, 2017). Recently, Manarin et al. (2021) examined the evolution of SoTL and stated that "From 2013-2017 [SoTL] continued to emphasize 'what works' in terms of teacher activity rather than 'what is' happening in terms of student learning" (p. 361). For the purposes of this study, SoTL has a dual focus. The first is from the perspective of the instructor-researchers to improve students' (preservice teacher) learning experiences in the science methods course by creating an authentic informal science education learning experience. The second SoTL focus is from a student-centered perspective. Using this SoTL framework enabled preservice teachers to assimilate authentic informal science experiences into their teaching pedagogy.

Teacher Reflection

Slade et al. (2019) discussed how real-world situations help teachers to reflect critically and develop new skills and knowledge. Avraamidou (2019) noted reflective practice in preservice teacher education is a process in which PTs utilize their lived experiences through community and culture to shape their own identities, and research on different levels of reflection and their impact have been examined (Catalana, 2020). In this study, we extended this

definition of reflection within the SoTL context to include the reflection experiences for both researcher and student around Rodgers' (2002) six phases of reflection: experience, spontaneous interpretation, identifying problems surrounding the experience, generating explanations, using the explanations to develop hypotheses, and experimenting with the implementation of the selected hypotheses.

Informal Science Education

The National Science Teachers Association (NSTA), 1998, defined informal science education programs as experiences developed outside the classroom by institutes and organizations including museums, science, technology centers, zoos, parks, etc. The National Research Council (2015) added an additional focus to informal STEM learning; a model emphasizing that a child's informal science education exists within a system of direct and indirect, interpersonal, cultural contexts. More recently the Center for Advancement of Informal Science Education (CAISE, 2019) reiterated STEM learning happens in places and through experiences outside of the classroom.

Through the lens of SoTL, the researchers believed that participating in an authentic informal science field experience would address the gap in their science teacher education program between classroom study and preservice teachers' development of their practice.

Previous Research Focused on Informal Science Education

Research on informal science education shows a positive impact on students (Habig, et al., 2021; Lin & Schunn, 2016) educators, and STEM careers (Habig, et al., 2018). Other studies have documented how informal science education experiences positively affect self-efficacy and beliefs in inquiry-based science teaching (Avraamidou, 2017; Douglass & Verma, 2022).

Several studies involving preservice teachers' practice with informal science education outside of a science methods course indicated positive results. Jung and Tunso's work (2006) showed PTs found experiential learning in science museums non-threatening, and the experiences helped develop their confidence in teaching. Similarly, a partnership between Towson University, the National Aquarium, and Baltimore City Public Schools resulted in increased understanding of content, gain in skills for effective teaching, and teacher confidence in science content for PTs (Haines et al., 2019). Skayia, Avraamidou, and Evagorou (2019) investigated SoTL-driven reflection via preservice teachers' journaling during informal science experiences. Analysis indicated informal science experiences have the potential to support PTs' development of their philosophies toward teaching science.

There have been several studies that incorporate informal science education as a portion of science methods courses. Kelly (2000) compared formal science with informal science settings in a constructivist-based elementary science methods course. Positive outcomes included impacts on scientific content and improved student attitudes about teaching science. Project Nexus (Riedinger et al., 2011), incorporated informal science education into methods courses through virtual field trips, guest speakers, and live animal demonstrations. Katz et al. (2013) investigated the effect of informal science education in a case study of two teachers with positive results. Most recently Douglass and Varma (2022) studied the benefits of placing elementary PTs in an informal, interdisciplinary STEM makerspace while they were enrolled in a science and math methods class. However, none of these studies looked at how experiences in an informal science education setting as a requirement of a science methods course.

Theoretical Framework

We framed this authentic informal science education experience using the social constructivist theory (Bruner, 2006) in a scholarship of teaching and learning mindset (SoTL). As per the social constructivist theory of learning, engagement is built on the assumption that learning is influenced by how an individual participates in educationally purposeful activities (Woolfolk-Hoy, 2019). We postulated that unlike the course's previous inauthentic informal science education assignments, the opportunity to practice science teaching off campus in an informal community setting would promote extrinsic as well as intrinsic values of informal science education.

Research Purpose

The purpose of the partnership was to provide practical, authentic experiences for preservice science education teachers with informal science education. Previously, the university science methods course included non-authentic experiences for course participants, which created a critical gap between pedagogy and practice. Providing PTs the opportunity to gain SoTL-driven, authentic experiences aligned to science curricula standards could effectively bridge this gap. This research has the potential to affect the efficacy of informal science education experiences of PTs and provide evaluative experience in informal science education in terms of value and applicability of teaching strategies for the PTs future classrooms. Therefore, the main research questions included:

1. **How does practice with informal science education in a science education methods course affect a preservice science teacher's efficacy for science?**
2. **How does practice teaching in an informal science setting impact effective preservice science teacher preparation for teaching in the science classroom?**

METHODOLOGY

Participants included elementary and middle school preservice science teachers (PTs) from the university, 46 third grade classes from the local public city school district, science education faculty from the university, and education program employees of the local children's science museum (see Table 1). The museum staff worked with us to provide the space for this experience, selection of activities to be taught, and professional development on campus in the methods class. The museum director was also interested in creating connections between the museum and PTs in order to expose them to the possibility of working in museum education in the future. This wish turned out to be fruitful, as a participant was hired to work as an educator at the museum (discussed below).

Preservice teacher reflections, observations, and assessment inventories were collected before, during, and after the informal science experiences. All the reflective processes completed by the PTs were developed through the context of SoTL as previously defined. Additionally, Rogers' (2002) six phases of reflection

Table 1. Participant numbers						
	faculty	**preservice teachers**	**museum employees**	**schools**	**classes**	**3rd-graders**
Fall 2018	1	17	2	13	21	734
Fall 2019	2	18	2	13	25	680
Totals	2	35	2	13	46	1,414

guided the researchers' implementation and facilitation of the PTs' reflections throughout the study. These reflective practices not only provided data for future revisions of the science content course, but assisted both the researchers and students in recognizing and bridging the gap between pedagogy and practice during class time on campus during the study.

In order to maintain confidentiality, all personally identifiable information was removed, and each PT was assigned a pseudonym kept in a password-secured digital format privy only to the researchers. The sequence of data collection events for this study are summarized in Table 2.

Table 2. Chronological Research Design Process	
Fall 2018	**Fall 2019**
Pre-STEBI	Pre-STEBI
Field Experiences	Review Focus Group
Reflection	Field Experiences
Post-STEBI	Observations
	Reflections
Code Student Reflections	Post-STEBI
	Code Observations and Reflections

In Phase 1, fall 2018 preservice elementary science teachers were given the *Science Teaching Efficacy Belief Instrument,* or STEBI-A (Riggs & Knochs, 1990; Moslemi & Mousavi, 2019) both pre- and post- of the informal science education practical experience. On the fourth day of the course, the PTs were taught content about electricity and performed three inquiry-based electricity investigations where they practiced initiating productive struggle (Lynch, Hunt & Lewis, 2018) and facilitation (Reeve, 2006). During the fifth class meeting, the education coordinator from the children's museum provided professional development related to the lesson each PT would lead during the field trip excursions for the 3rd-grade students (20-25 students per session) at the museum.

Description of the Inquiry-Based Engaging Lesson

The format of the lesson, *Spotlight: Electric Lesson Plan*, (Table 3) included an engaging introductory activity using an energy rod, open-ended questions connected to real-world applications of electricity, a video on the energy grid, a review of the electrical grid challenge, facilitation and troubleshooting collaborative groups during the activity, and additional enrichment challenges for those students who completed the energy grid activity earlier than their classmates.

Each PT was required to lead one field trip in two sessions split over 2 hours. Ten of the preservice teachers in fall 2018 (59%) volunteered to lead additional informal science sessions and were encouraged to make changes to effective teaching strategies as needed. The preservice teachers used SoTL practices as researchers by questioning, gathering evidence, and trying out and redefining new thoughts in their reflections (Huber & Hutchens, 2005). Specifically, upon completion of the field experience, the PTs wrote a reflection that included: a description of events, their role, reaction to the experience, application to future classroom, student impact with inquiry, and connections to pedagogy, text, and curriculum alignment. In addition, the researchers used descriptive qualitative analysis (Creswell, 2013; Miles, Huberman & Saldana 2019) to manually code the reflections. Three members of the research team checked each reflection: a science education faculty member, an undergraduate student researcher, and a museum education specialist.

In an effort to validate the findings from the reflections, (Menon & Azam, 2021) a focus group of PTs from the previous semester's science methods course was conducted. Three of the

Table 3. Spotlight: Electric Lesson Plan Summary	
NGSS	3PS2-3 Motion and Stability: Forces and Interactions Science and Engineering Practices: Asks questions and defining problems Disciplinary Core Ideas: PS2.B Types of Interactions: Electric Crosscutting Concepts: Cause and Effect
Introductory Activity (engage)	The teacher facilitates engaging introductory activity using a small group of students to demonstrate. Students form a small circle and join hands. Two students hold the Energy Stick. The teacher directs two other students to break the bond. Discussion and real-world application.
Pre-assess and engage	Open-ended class discussion. Example questions include: • What things do you have at school or at home that use electricity? • Where do you think electricity comes from? How does the electricity get to where you live or your school? • Has there ever been a storm and the electricity went out? How do you think the electric company knew to come to fix the electricity? (leads to energy grid)
Video	Smart Grid: https://www.youtube.com/watch?v=4L31dHXP6i0.
Review of electrical grid challenge	"We are going to work in four teams to solve a challenge to connect homes to electricity." The teacher discusses setup, rules of the challenge, connections to previous video and activity, and troubleshooting issues.
Collaborative group activity	Students work in teams to connect wires from a power source to homes via transformers and transmission poles. The teacher encourages teamwork, facilitates learning, troubleshooting by asking questions and while avoiding solving the problem for them, keeps them on time, and checks for blown fuses.
Enrichment activity	Groups who finish early will be challenged to incorporate a switch at various places.
Evaluation	The teacher will ask students to describe the challenges and successes with the activity.

Table 4. Preservice Teacher Observations								
Student	**Rachel**	**Debbie**	**Nancy**	**Kelli**	**Nick**	**Savi**	**Helen**	**Savi**
Date	4-Oct	4-Oct	9-Oct	9-Oct	21-Oct	21-Oct	12-Dec	12-Dec
Length of observation	2 hrs	1.5 hrs	2 hrs	2 hrs	1.5 hrs	1.5 hrs	2 hrs	2 hrs

17 contacted agreed to participate. The focus group was audio-recorded and additional field notes were collected by the undergraduate researcher. The audio recordings were transcribed and analyzed by the research team for themes that corresponded to the reflections.

During the spring 2019 semester, the informal science experience was repeated with a new group (n=18) which included 15 elementary and 3 middle school preservice teachers. Each PT led a minimum of one field trip (2 hours) with 12 of the 18 (67%) choosing to lead multiple field trip educational experiences at the museum. In addition, eight random 1.5 to 2-hour field observations were conducted to examine PTs teaching in action for themes noted in the first cohort (Table 4).

Each PT in Cohort 2 completed a reflection with criteria identical to that of the first cohort: a description of events, their role, reaction to the experience, application to future classroom, student impact with inquiry, and connections to pedagogy, text, and curriculum alignment. The faculty and undergraduate researcher coded and analyzed the reflections of Cohort 2, first separately and then collaboratively.

At the conclusion of the study, STEBI-A pre- and post- scores for each semester were compared to previous courses that did not include the strategic intervention (field experience at a children's museum). Thirty-one of the 35 preservice science teachers completed both pre and post-tests. Using a paired t-test (Hair, Black, Babin, & Anderson, 2018), the results of the preservice teachers (n=31) indicated that post-test scores (μ= 4.6) were significantly higher ($p < 0.0001$) than pretest scores (μ= 3.6) with measurable increases for all. The post-test scores were also significantly higher than the previous science methods courses that did not include the informal science education field experiences (4.1, p<.05). Therefore, the quantitative data indicates that science teaching efficacy for preservice science teachers in the science methods course increased with the informal science education experience.

Coding Results

Upon analysis of data collected from Cohort 1 we coded reflections that demonstrated areas of development and growth of the PTs. Then we investigated each area through a focus group, the second-year cohort, and field observations at the children's museum. As we analyzed the qualitative data, multiple themes emerged in support of including authentic informal science experiences in science teaching methods courses. These included: increased self- and content confidence, development of positive attitudes towards science, positive experiences of teaching through inquiry-based instruction, the improved value of deeper learning, practice with classroom management and planning, student collaboration struggles, and increased knowledge of lesson and field trip preparation.

Confidence Increased in Both Teaching Ability and Scientific Content

When teaching their lessons, several participants experienced a benefit from learning about teaching strategies. For many, this was the first time they were exposed to teaching science in any form, let alone in an informal setting. PT Harold shared, "I was learning it for the first time all over again...I definitely learned something about the content and myself." Participants are able to apply the methodology they learned in the science method course, and fit this newfound knowledge into their evolving teaching styles. The experience led participants to explore their understanding of teaching and science content and grow confident with their abilities in both areas. One participant from the focus group noted:

> It really helped me get comfortable in [a] temporary teacher-like atmosphere… seeing how much… support [is needed] of the students and… encouraging them to ask questions really helped. [I am] A million percent more confident… I was not a science kid. (Celia)

Results from Cohort 1 were mirrored by the experiences of Cohort 2 which also showed strengthened confidence in both teaching abilities and scientific content. Katzia said: "[Initially] I was nervous that the students were going to ask questions that I did not know the answer to… [Afterwards] I felt slightly more comfortable teaching the lesson and the content." Another Cohort 2 member, Judy, expressed her confidence this way:

> I actually learned a lot about the content we were teaching, myself… The way that this experience helped me, a 21-year-old college student understand the topics better made me really understand how important inquiry-based, hands-on experiences will be to my future students while they learn science.

Confidence, both in teaching and in scientific content knowledge, was noted by most participants as a direct benefit of the informal experience. This was also supported by the increased science efficacy scores.

Positive Attitudes in Preservice Teachers Toward Teaching Science

Before their informal science experience, the PTs mentioned that science was often an afterthought in the elementary curriculum, rather than core content. For example, Harold stated, "In my novice placement, we only teach to the math and reading standards. The only science, if any, we teach is tied in with literacy." The lack of teaching science in field placements had made participants hesitant about the content and their ability to teach it and as a result, failed to nurture a positive belief to teach science in their future classrooms. After the informal science teaching experiences, participants' reflections revealed changes in their perceptions. Harold stated, "This was a fun activity to be able to teach science on its own. Science can still be engaging and exciting when it's tied in with the curriculum." Penelope echoed this idea: "This experience changed my perception by taking one subject

matter [electricity] and differentiating it for younger students even though it seemed to be a higher-level thinking."

Not only did the PTs say they had changed their perceptions toward teaching science, but they had begun to enjoy teaching science as part of the curriculum. Adisa noted her positive change in attitude when she stated, "I had a lot of fun at the museum and wish I was able to go again. This experience taught me how fun and engaging science is and how important it is to incorporate science into the curriculum." Other participants reflected on their newfound eagerness to teach science in their future classrooms. Peter, in Cohort 1 reflected, "Both this service-learning opportunity and all of our classroom activities have given me a strong framework for using inquiry in my future classroom, and I can't wait to get started."

Members of Cohort 2 similarly reflected that the experience was positive and influenced their interest in teaching science in the near future. Eliza, for example, expressed this when she said:

> It was fun to see the students having aha moments when creating the circuit because they understood where power [came from]…I learned a lot from this experience, and I will apply this into my classroom to teach science lessons in the future.

Several others in Cohort 2 said they enjoyed the experience enough that they received positions teaching science at the children's museum or another local museum. Darius for instance: "I absolutely adored this experience which then caused me to apply for a job at a museum. I ended up getting the job, so I currently work there and absolutely love it all because of this experience." There were no particularly negative findings, other than some participants expressing nervousness before teaching. Throughout this research, a majority of participants from both cohorts, and the focus group reflected that the informal science experience positively impacted their attitudes and perceptions toward teaching science in the future. This was evident when several PTs chose to continue the informal science experience beyond the assignment time, as well as the increased science efficacy scores mentioned early.

Gained Experience Teaching and Facilitating Inquiry-Based Instruction

Aside from becoming comfortable, confident, and positive about teaching science, the PTs expanded their understanding of classroom practice, specifically with inquiry-based instruction. At the museum, PTs had to think quickly and creatively as their students had different experiences with inquiry-based instruction. As noted by Constant et al. (2018) and supported by Kazempour et al. (2020), establishing a classroom culture of inquiry that employs aspects of the 5E Model (engage, explore, explain, elaborate, evaluate) is essential to the foundation of inquiry-based instruction. Without it, educators often have difficulty utilizing inquiry as a way for their students to explore scientific content. The PTs in this informal space needed to use the methods they had learned and improvise their pedagogy to not only put those methods into action, but to also create an environment for student inquiry. Bruno expressed how he adapted inquiry-based pedagogy to the needs of his students: "To me, this [informal experience] shows that when I am teaching science concepts, I need to explain it in a variety of ways and with a variety of examples, so every child has the potential to understand it."

Notably, one focus group member reflected upon how the informal science experience had impacted their own teaching practices when they moved onto student teaching:

> Yes, this learning experience was helpful. In my student teaching experience administration came in 10 minutes before the students arrived and said you need to teach science content now. I only received one resource manual with talking points. The administration was impressed, the parents were excited to see their child's ability and differentiating was now easier to meet the needs of K-3 grades. (Penelope)

Cohort 2 PTs discussed how they adapted their pedagogy to the informal space to provide an inquiry-based lesson for their students. Helen improvised a style of establishing inquiry similar to the rest of Cohort 2. She reported success during her lesson at the museum:

> Instead of telling students… I only told them how to use each piece of equipment. It was up to them to work together… It was interesting, engaging, and rewarding when they finally figured it out. [The students] made far more connections and learned the material more thoroughly when they learned through productive struggle in inquiry.

When given this opportunity to practice in an informal science setting, PTs strengthened their ability to teach and facilitate inquiry-based instruction by adapting their pedagogy and gaining the experience of practicing the promotion of the essential features of inquiry (National Research Council, 2002; Constant et al., 2018) in a non-traditional environment.

Enhanced View on the Impact of Deeper Learning Through Authentic Facilitation

In their science methods course, the PTs were instructed on the benefits, application, and practice of teaching through deeper learning, or academic content mastery (Parsi, 2016), in their classrooms. In the informal experience, the PTs applied the methods they learned in the course to create deeper learning in an environment that was non-threatening, but similar to a regular classroom setting (Douglass & Varma, 2022; Jung & Tonso, 2006). As a result, participants explored the impact of using deeper learning via real-world applications in their own teaching and thus experienced a positive change in their view of deeper learning. As Harold said, "Participating in the learning activity with their [the 3rd graders'] field trip seemed to allow them to explore more of the content and why it's important in their daily lives."

The PTs used the informal science setting to further their student's connections of the energy curricula to real-world experiences. By doing so, they noted the impact that deeper learning strategies had on their lesson. Celia reflected, "If you ask the right questions to support them and begin to answer their questions with even more questions, they are going to be prompted to continue to learn… to continue to explore that topic deeper." Elisa furthered this idea by commenting, "I see myself applying this [deeper learning] to science teaching because this lesson shows how beneficial a lesson can be that engages the students and connects to their own lives."

Following the informal experiences of Cohort 2, PTs in this cohort applied their experiences similarly to Cohort 1. Both cohorts utilized student-led inquiry related to the concept of energy and how it relates to our society. Additionally, both cohorts understood that the elementary students had varying

levels of background knowledge. As such, PTs in both cohorts differentiated their lessons to access this knowledge and establish a deeper learning experience. Kaser included an example of this in his post-experience reflection:

> To start this lesson, I asked the class to share what they already knew about electricity. I was surprised that the students knew a lot of prior knowledge about how electricity works. Students then inferred what would happen to their own power grid if it was not set up correctly… They were interested to learn about how all of this related to their lives for some groups I was able to move along quicker, and with other groups, I focused on building a solid [conceptual] foundation.

In one instance when a member of Cohort 2 moved their style of teaching away from deeper learning based, they found a negative impact. Nick detailed how the lesson suffered as a result:

> Upon reflection, I realize that my methods reverted to a traditional style. I wrongly front-loaded the activity rather than connecting the activity to the real world and its implications. In my future classroom, I'll anticipate this switch and work to improve my ability to establish deeper learning for success.

The opportunity to experience informal science teaching in the museum setting allowed participants to view deeper learning positively as a practice they could use in their future classrooms. Participants were able to develop this enhanced perception of their role through the authentic experiences they established to create deeper learning.

Practice with Classroom Management and Planning

Many of the PTs discussed how they struggled with managing student behavior outside of an established classroom, especially with elementary students on a field trip. Jim, stated that "When teaching the lesson, I saw how chaotic and curious the students were about this subject." Despite the difficulties the participants encountered, the informal science experience enabled PTs to practice adjusting their classroom management skills in real-time. Kassie said, "Students struggled to collaborate, so I had them put everything down and discuss their plan and take things one step at a time… I did not tell them how."

After the experience took place, participants reflected on their actions as teachers to uncover how they could improve their ability to teach science. Celia and Rosalie thought about how to improve lesson and field trip planning as a means of combatting classroom management issues, especially in an informal space. Celia noted, "I feel that teachers should be engaged, teach the content prior, and support the students in the activities of the field trip." Rosalie reflected, "Organization of students with exceptionalities must be addressed… additional scaffolding could be needed."

The second cohort experienced struggles similar to the first group. Interestingly, on reflection, many PTs in Cohort 2 took an extra step not only to plan and remedy classroom management but to figure out how to accommodate students with exceptionalities into their lessons. Cruse discussed how he tried to accommodate hearing-impaired students:

> During one of our classes, we had a few students with hearing impairments. As a result, we had to make adjustments to how we taught. We provided subtitles… [we ensured] students were able to see all demonstrations… we spoke at a speed that allowed the interpreter to appropriately convey what was being said. In the future, I will be sure to make extra considerations to meet the needs of these students.

Another PT experienced classroom management issues when a bilingual class visited the museum. Noticing the difficulty the students were having understanding the lesson's content, Sinbad reflected upon possible future accommodations and modifications for Multilingual Learners (MLs):

> The second group was the bilingual class… The person in the video talked very fast and it was hard [for students] to keep up. They became distracted and off-task. In the future, I will provide modifications for students with special needs or ML students such as providing an interpreter, subtitles, realia, etc.

Through this experience, the PTs experienced issues that can arise from elementary students in an informal space as well as on a field trip. Additionally, participants in Cohort 2 began to gain an understanding of the adaptations and modifications needed for students with exceptionalities when visiting informal spaces. As a result, the PTs gained real-world experience in tackling these issues and reflected on how they will organize their own field trips to informal spaces to better create effective learning experiences for their future students.

Experience with the Struggles of Student Collaboration

Nearly all of the PTs reflected on an instance where their students had difficulty cooperating during the electricity lesson. In these situations, the PTs had to put into practice what they learned about collaboration in past methods courses to inspire student effective collaboration. Chandra guided her students to restart the inquiry process. She explained, "I told them to put the wires down. Talk about how they are going to do it, then assign parts to each member." Kassie used a similar method to help her students collaborate and saw positive results. She shared, "We went through the procedure, asked questions, and helped prompt students… Students who came in looking disgruntled or disinclined to learn were leading the team and supporting their fellow students."

Other PTs who were not as successful with collaboration later reflected on their teaching and ways to improve their teaching in the future. Jim noted:

> The lesson was a lot of fun and clearly a success, but I did see some areas that could be improved. One thing I noticed was how students kept getting left out or taking control of the activity. To fix this I would have liked to give each student in every team a role to perform.

In the second cohort, the PTs also relied on transferring knowledge from the methods class to the informal science experience to facilitate collaboration. Katzia described it this way:

> I was able to connect a few concepts that we have discussed in class. One major concept was collaboration. The students had to collaborate… It was a little difficult to tell students I did not know not to fight over things and that everyone needs to play a part. However, once I facilitated, students started talking to each other instead of grabbing things from each other the process flowed more smoothly.

By facilitating student collaboration and reflecting on their actions, these PTs experienced how more seasoned teachers can work to improve their teaching and their students' learning.

Garnered Knowledge of Careful Lesson and Field Trip Preparation

Lastly, the PTs learned how to prepare effective content lessons and to consider field trip opportunities for use in their future classrooms. They frequently reflected on how they prepared for and executed all aspects of the experience. Elouise said "This was also a good experience to see the importance of adaptations and scaffolds in science instruction. Importance of consistency is crucial for the preparation of the lesson… Field trips should be... connected to the content." Celia added, "Designing lessons that allow students to make mistakes is a natural part of the lesson design process [and] is critical."

During Cohort 2's experience, PTs learned additional ways to prepare for future classes and field trips. For example, Becky considered how she might do a post-experience assessment with students:

> A post-assessment I would do is a class discussion. I would have the class come together and discuss what we learned. I would also have a poster board so we could write down the important takeaways. When we were done with the discussion and writing our ideas, I would then hang the poster up so we could look at it throughout the year.

In the reflections written by the preservice teachers after their informal science experience, participants expressed their intent to apply their new ideas and knowledge to their future lessons and field trip planning.

DISCUSSION

NSTA advocates that preservice science teacher programs expand the role of informal science and the development of systemic links between formal and informal science education, but this is not commonplace. This study found when PTs have opportunities to practice teaching without the stress of observation and assessment they experience during student teaching, they improved their self-confidence, and made positive connections between inquiry-based science teaching strategies and science content. The researchers believe that given the opportunity to teach in an informal science education setting, the participants gained confidence through *doing* rather than listening to a lecture or participating in the more usual college classroom inquiry experience. Additionally, because the PTs became facilitators of real-world experiences, they found value in hands-on activities and the importance of creating a culture of inquiry in the classroom. The field experiences embedded in their methods course provided them practice in classroom management and adjusting strategies for lessons as the need arose in real-time, just as effective teachers do.

The findings were obtained through the implementation of SoTL-based, authentic experiences and reflective practices akin to Huber and Hutchings (2005). The preservice teacher participants' reflections then pushed them to think more critically, to redefine and discover what did and did not work in teaching science in an informal, real-world setting (Slade, et al., 2019). These SoTL-based processes were at the core of the study and when compared to non-authentic, artificial experiences, the implementation of SoTL-based processes contributed to these PTs' self-efficacy related to science pedagogy. Further research is suggested to better understand to what degree such practices and reflections benefit preservice teachers' self-efficacy in science pedagogy.

Some of the findings of this study are similar to other research involving students engaging in informal science, as mentioned previously. However, when informal science education became an integral field experience within a science methods course as in this research, additional benefits were found. The reflection process for the participants brought to the forefront increased efficacy for science, specifically for the PTs who were not comfortable with science and the teaching of science in a classroom setting. In addition, the preservice teachers appreciated the opportunity to practice classroom management skills in the informal science setting before student teaching. They also expressed the value of aligning field trips with science curricula, adding to the validity of why their students need to learn science. The PTs found field trips that engage students in deeper learning experiences create connections between classroom science content and real-world experiences for both themselves and their students. Additionally, the preservice teachers connected what they are learning in their methods course by putting those strategies into practice in a real-time, real-life setting. Lastly, they felt the experience of practicing their craft in an informal science setting increased their comfort with facilitating student collaboration in order to create deeper learning experiences. The overall findings of this study support, and are supported by, the results of other SoTL-based studies that measured interventions related to reflective practices (Catalana, 2020), and experiential service-learning (Gormally, 2009; Furguson, 2019; White, 2021).

There were a few additional outcomes of this study that have the potential for future studies. One that was not expected was how some preservice science teachers reflected on accommodations or adaptations that they used to assist diverse students such as students with exceptionalities or Multilingual Learners (MLs). If they were unable to make the necessary accommodation or modification on the spot, the PTs reflected on the future changes they would make to adapt their lessons in both an informal and formal classroom setting. Secondly, even though this research specifically related to informal science education experiences, several of the preservice teachers mentioned their experiences in informal settings could be applied to other content areas. In the future, partnering math, social studies, or English methods students with students in a science methods course could provide a unique opportunity to explore the interdisciplinary benefits of informal educational experiences. Additionally, more focus on experiences that have connections to students' cultures (Djonko-Moore, et al., 2018) is another area that would benefit from additional research.

CONCLUSION: IMPLICATIONS FOR SCIENCE TEACHER EDUCATION PROGRAMS

While authentic experience with teaching science in an informal setting is not a common practice in university science teacher methods courses, the results of this research provides evidence that education faculty should consider including such field experiences in these courses. In this project, because we are situated in a small city where the university has strong connections

with organizations and the public schools in the area, and the children's museum is located just 2 miles from campus, we did not have logistical issues, which we recognize may not be the case for everyone. We feel it is worth the effort to move from a non-authentic, virtual informal science experience to authentic field experiences in informal science education, as based on the outcome of this research. It is our belief as evidenced by this study, that the positive, authentic experience improved the participant preservice teachers' science methods course experience at this particular university.

Teaching is about making connections (Kumpulainen, K. and Sefton-Green, J., 2014), and the connection between classroom curricula, field trip planning, and execution isn't always clear for preservice teachers (Subramaniam, et al., 2018). Every activity, lesson, or discovery in a science class should be designed to provide those connections between content and process, including the alignment of field trips to curricula. In addition, preservice teachers are not always provided authentic field experiences to create the connections in the informal science setting between pedagogy and practice. Designing activities in science teaching methods courses or other disciplines that include authentic experiences, as evidenced in this research, provides a much-needed connection between content and practice. In addition, using the SoTL framework as a guide for the improvement of practice and design with preservice science teachers in the course, gave them a sense of how to improve instruction effectively and a way to communicate the effectiveness of the changes to others. Additionally, utilization of the SoTL framework alongside the social-constructivist foundation of the study would imply that the study findings could have an international scope as others seek to improve their science teacher educator programs. Therefore, we believe this study supports inclusion of practice with informal science education in science methods courses as means to fill a gap in preservice teaching experiences, as well as provide ease of transition in science teaching from the university to the classroom for new teachers.

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