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Pre-service teacher perceptions of an outdoor learning experience within a science methods course

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ABSTRACT

Given the challenges currently facing early childhood science education, this exploratory study investigates the advantages of outdoor learning as part of a teacher preparation program. A group of 49 pre-service early childhood education teachers participated in a day-long outdoor learning experience embedded within their science methods course. Guided by the theoretical lens of embodied cognition, we employed a case study approach to collect and analyze qualitative survey data, using both categorizing and connecting strategies to explore participants' experiences. The findings reveal four key themes related to pre-service teacher perceptions, in that outdoor learning: (1) represented an engaging experience, (2) contributed towards knowledge and skill development, (3) built the community of pre-service teachers, and (4) impacted frameworks for future classrooms. This research contributes to the growing literature on experiential learning in teacher education and highlights the importance of providing pre-service teachers with opportunities to engage in authentic, embodied science experiences.

Keywords: science methods course, outdoor learning, preservice teacher education, early childhood science education

INTRODUCTION

It is time to rethink the ways in which we prepare pre-service early childhood teachers to be effective science educators given the challenges they will face in their future science classrooms. Limited resource accessibility, lack of teacher confidence, minimal science background knowledge, insufficient instructional time, and other barriers can stand in the way of high-quality early childhood science instruction (Banilower et al., 2018; Carrier et al., 2024; Maeng et al., 2020). We know that, in order for young students to successfully learn science knowledge and skills, they need to experience a variety of instructional approaches that contribute towards their science proficiency (National Research Council, 2007). The next generation science standards (NGSS) have been in place for over a decade, yet there remains a need for innovative approaches to science teaching that address the areas where the NGSS may not fully capture all opportunities for impactful learning (Merritt & Bowers, 2020). For instance, outdoor learning has been considered a promising approach to overcoming obstacles in traditional school-based science by enhancing accessibility and cultivating a positive interest in science (Hammack et al., 2023). Previous research indicates that science can become more accessible when educators use a variety of pedagogical strategies to instruct in the outdoors (Dean, 2022). Yet the literature is limited when it comes to ways to develop pre-service teachers' skills or prior experience with outdoor learning as integrated within science education. This exploratory study fills the gap by seeking to understand the impact of outdoor experiences on pre-service teachers as embedded within a science methods coursework. The research question that guided the inquiry was: *What are pre-service teachers' perceptions of a day-long outdoor learning experience within an early childhood science methods course?*

LITERATURE REVIEW

Our study is rooted in literature that explores the challenges and opportunities for pre-service teachers in early childhood science education, focusing on NGSS-aligned instruction and outdoor learning. We also present embodied cognition as a theoretical framework as a way to anchor our study and provide an effective lens through which to enact our research.

Pre-Service Teachers and Early Childhood Science

Because early childhood is often defined as birth through age eight, we include elementary science education literature

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to represent the K-3 grade band in the United States. In 2012, the NGSS were adopted for grades K-12, encompassing three main aspects of science education: disciplinary core ideas, science and engineering practices, and crosscutting concepts. The NGSS emphasize how students' understanding of complex phenomena relies on intricate mechanisms, which teachers must first grasp and then effectively explain to their students. Teachers need to comprehend these mechanisms before they can help students make sense of such topics in a meaningful way, even at the elementary level (Fauth et al., 2019). The science instructional approaches that elementary teachers use are referred to as inquiry-based cognitive activation strategies. Cognitive activation involves engaging students in higher-order thinking through challenging, well-paced tasks while building on their prior knowledge and reasoning processes (Praetorius et al., 2018). These practices are unique to science and typically include activities that reflect cognitive processes used by scientists during scientific practices (Rönnebeck et al., 2016; Teig et al., 2019).

However, many elementary science teachers lack self-efficacy when it comes to effective science instructional practices and this can hinder students' scientific development (Fauth et al., 2019).

> If teachers perceive weaknesses in themselves, they are less likely to teach science, and there will be a cycle of either poor or little science teaching at the elementary levels, so there needs to be an emphasis on improving teachers' knowledge and practice to ensure effective science teaching takes place (Akerson & Bartels, 2023, p. 49)

This concern is echoed in broader research showing that teachers with low self-confidence in science instruction are also less likely to implement effective, student-centered teaching practices, such as inquiry-based cognitive activation strategies (Teig et al., 2019). This association may reflect teachers' inadequate science knowledge and beliefs that hinder them from using such approaches and lead them to favor low-risk instruction such as lecture-driven lessons (Murphy et al., 2007; Teig et al., 2019).

Typically, university coursework does not significantly increase elementary teachers' self-efficacy in science. DeJarnette (2018) found that elementary pre-service teachers are not generally trained in STEM teaching and very rarely in STEAM education. However, NGSS-aligned courses that emphasize discovery, inquiry, and collaborative learning have been shown to boost pre-service teachers' confidence in their cognitive science skills and attitudes toward teaching science (Akerson & Bartels, 2023). Additionally, opportunities to practice teaching science through embedded fieldwork courses and targeted PD that models inquiry-centered science lessons, nature of science (NOS), and project-based learning have proven more effective in enhancing pre-service teachers' self-efficacy to deliver science lessons compared to traditional, standalone field experiences (Akerson & Bartels, 2023; Clark & Newberry, 2019; Donna & Hick, 2017; Maeng et al., 2020). These opportunities help to produce teachers who express joy and enthusiasm while teaching and, in turn, are more successful at engaging students and sparking their interest in the subject matter (Fauth et al., 2019). These findings highlight the importance of experiential learning in building teacher confidence in science instruction.

Outdoor Learning

While inquiry-based instruction remains the dominant approach recommended in elementary science education, it is not bound to indoor, lab-like settings. Rather, scientific inquiry can be meaningfully enacted in a variety of contexts, including the outdoors (Čiháková, 2024). Both inquiry and outdoor learning emphasize active, student-centered engagement and experiential learning, yet they differ in context and structure. As the name suggests, the context of outdoor learning is in a natural environment and refers to a pedagogical approach aligned to the school-based curriculum while situating learning in nature (Barfod & Bentsen, 2018; Beames et al., 2024). Structurally, outdoor learning encompasses a range of school-based learning activities that take place in outdoor settings, either on school grounds or within the local region (Marchant et al., 2019). While it can take on a variety of forms, it consistently occurs in natural environments (Waite, 2020) and serves as a complement to the classroom instruction (Nikbay Arslantaş & Bavlı, 2024).

Specifically pertaining to science education, outdoor learning can contextualize state- or nation-mandated standards, such as the NGSS (Ayotte-Beaudet et al., 2017). Some scholars recognize how outdoor learning can expand upon the Western construct of science embedded within the NGSS to include other knowledge systems and scientific ways of knowing (e.g., Merritt & Bowers, 2020; Stroupe & Carlone, 2022). The natural environment serves as a laboratory for science and an authentic context for students to engage in scientific processes (Eick, 2012). When considered together, inquiry-based science instruction and outdoor learning hold significant potential. Outdoor settings can serve as rich environments for NGSS-aligned inquiry, particularly when students are given the opportunity to engage in authentic wonder regarding local, place-based scientific phenomena (Dean & Gilbert, 2021). Thus, outdoor learning should not be seen as distinct from inquiry but rather as a powerful medium through which inquiry-based science education can come to life.

Outdoor learning offers opportunities to enhance NGSS science instruction, making it more relevant and accessible through local phenomena (Hammack et al., 2023). However, many pre-service teachers still struggle to implement inquiry-based science, particularly in traditional laboratory settings where instruction often defaults to step-by-step procedures rather than authentic investigation (Valls-Bautista, 2021). When outdoor learning is infused within a science methods course, pre-service teachers can have opportunities to experience authentic investigations and discover ways that the natural environment can engage students in inquiry-based cognitive activation strategies.

Embodied Cognition Theoretical Framework

In considering cognitive activation strategies in science education, *embodied cognition theory* posits that human cognition is an interaction between the brain, body, and environment rather than solely a function of the brain (Fan, 2023; Ye, 2010). This theory challenges traditional views of the

body as passive during learning by emphasizing the role of physical activity and movement in shaping cognitive processes (Fugate et al., 2019; Ye, 2010). Cognitive understanding is thus "constituent to" rather than independent of the body (Leitan & Chaffey, 2014, p. 3), with experiences embedded into the brain through sensory interactions with the environment (Fugate et al., 2019).

Advances in neuroimaging confirm this interconnectedness, showing that cognitive processing is deeply rooted in sensory and motor experiences (Macrine & Fugate, 2022; Wilson & Foglia, 2016). This has led to a significant shift in psychology, highlighting the central role of the body in shaping thought (Fugate et al., 2019). In the context of outdoor learning, for example, students' physical interactions with nature can significantly impact cognition, as these embodied experiences anchor abstract concepts to the real world (see Shapiro & Stolz, 2019). While nuances exist within the embodied cognition framework, all perspectives acknowledge that thinking is situated in physical experiences, which profoundly shape understanding (Macrine & Fugate, 2021).

Many educational practices still favor a disembodied approach to learning, however, and this tendency is especially pronounced in teacher education where curricula often rely on passive knowledge transmission (Macrine & Fugate, 2022). As Macrine and Fugate (2022) note, American classrooms have lagged in incorporating embodied cognition into teaching practices, frequently focusing on abstract concepts without engaging students' sensory-motor systems. Nonetheless, embodied cognition holds specific potential within science education, as seen when students physically engage with scientific phenomena or use gestures as a form of argumentation (Macrine & Fugate, 2021). Although this framework has not yet been explored in outdoor learning within pre-service science methods courses, it offers a promising direction for theoretically grounding our study by connecting concepts to physical experiences.

METHODS

The overall aim of this case study inquiry was to understand a cohort of pre-service teachers' perceptions of an outdoor learning experience that was a required part of their science methods course. Our motivation for this case study is instrumental; that is, we wanted to facilitate understanding of pre-service teachers' outdoor learning experiences, a specific issue of our case that is connected to our own practice as science teacher educators (Hamilton & Corbett-Whittier, 2013).

Participants and the Outdoor Science Learning Experience

This study took place at Lentmon University (pseudonym) in the Southeast region of the United States. Early childhood educators at Lentmon are required to take both a science methods course and a social studies methods course in their junior year. The professors of these methods courses collaborated and designed a six-hour outdoor learning experience in lieu of two separate classes as a way to highlight the integrative nature of outdoor learning. There were 49 pre-service teachers present on this day, and class was held at a large nature center. The professors facilitated a variety of learning structures throughout the day, including an interactive introductory presentation inside, four outdoor learning stations, independent outdoor journaling, and collaborative unit/lesson planning. All of the science activities were fully integrated into the local outdoor environment, meaning that the landscape and natural materials were essential for learning (see Beames et al., 2024). Rather than simply situating science inquiry *in* nature, we taught *with* nature, fully incorporating the outdoor environment (see Butler, 2024). For example, at the water filtering station, students engineered their water filters right at the lake's edge, using locally sourced stones and sand that they had to find. **Figure 1** illustrates each part of the day's schedule. Although the outdoor learning experience included social studies methods, we focused particularly on the science education component for the purposes of this study.

Data Source and Collection

In order to examine how pre-service teachers perceive outdoor learning experiences within their coursework, our data collection process involved a follow-up survey after the class was held at the nature center. This survey was originally designed by the methods professors to elicit feedback from students to inform future direction of instruction. At the conclusion of the outdoor learning experience, the pre-service teachers completed a Google Form that included six open-ended questions and one multiple-choice question (see **Appendix A**). After realizing the rich potential it offered, the survey data were ethically obtained from the course methods instructor. Because this survey data was deidentified, the authors' university ethics board stated that formal approval was not needed. The research team emailed students requesting to use this deidentified data, and students were given the option to opt out if they did not want their responses included. We ended up with 49 participants since no student opted out. While the survey was not originally created for research purposes, it offered rich qualitative insight into participants' lived experiences and perceptions. Preexisting documents, such as open-ended surveys not originally designed for research, can still serve as valuable sources of qualitative data when contextualized appropriately (Creswell & Poth, 2018; Patton, 2015). In this study, such data are treated as naturalistic and exploratory, consistent with the interpretive goals of qualitative inquiry (Sherif, 2018). And although the original survey did not include questions explicitly focused on science teaching and learning, the responses revealed meaningful connections between outdoor experiences and participants' developing views on teaching science. The open-ended nature of the questions allowed pre-service teachers to reflect broadly, offering insight into how outdoor settings shaped their thinking about inquiry-based instructional practices, student engagement, and curriculum relevance.

Data Analysis

Case studies can have a flexible methodology and versatile design approach (Pearson et al., 2015). In fact, there can be multiple ways of pursuing case study data analysis as long as

Time	*Description of Activities*
8:15-9:15	Interactive presentation on outdoor learning and integrated approaches
9:15-9:30	Short break^
9:30-10:30	First two rotations*
10:30-11:00	Independent wonder journaling
11:00-12:00	Second two rotations*
12:00-12:45	Lunch and break^
12:45-1:45	Application and reflection

^ Students were encouraged to explore the nature center during breaks, either with peers or individually
* The four stations were:

1. Team Building and Community
Builds social-emotional connections through movement and collaboration in open, natural spaces, using the landscape to foster trust and community.

2. Environmental Science Curriculum Exploration
Engages students with environmental science lesson plans in direct connection to the environment, using outdoor settings to deepen comprehension through sensory and contextual experiences.

3. Nature's Materials Lab (STEM Egg Challenge – 2-PS1-2)
Encourages students to explore the properties of natural materials like leaves, sticks, and soil while engineering protective structures for an egg.

4. Clean Water, Local Solutions (Water Filtration – 2-ESS3-1)
Frames environmental engineering as a local challenge, using found outdoor materials to filter lake water and connect science to real-world, place-based needs.

Figure 1. Schedule of the science methods course at the Nature Center (Source: Authors' own elaboration)

the contextualized phenomena is effectively described and interpreted (Johnson & Parry, 2022). Thus, we followed Maxwell et al.'s (2014) qualitative analysis related to examining our data for two key types of relationships: similarity and contiguity. This approach is situated in theory and presents the nuances of analyzing qualitative data in a way that is both rigorous and flexible. Our analysis was also informed by Braun et al.'s (2021) qualitative survey analysis methods which can lead towards "nuanced, in-depth and sometimes new understandings" of data (p. 641). **Table 1** displays our data analysis steps as well as a description of each.

Table 1. Data analysis steps and description

Step	Description
1	- Read through survey responses and take individual notes - Write summary memos
2	- Discuss thoughts as research team - Code for substantive categories
3	- Search for contiguity relationships using connecting strategies - Display relationships in a visual map (**Figure 2**)
4	- Focus on four themes that highlight the experience
5	- Incorporate numbers to complement participants' perspective

Our first step was to read through the survey responses, individually taking notes and noticing tentative categories amongst the data. We then re-read student responses to each question and wrote a summary memo of similarities that we noticed, tracking our notes using the comment feature on Google Docs. During step 2, the research team discussed our thoughts before beginning to code for substantive categories - descriptive phrases that remained close to the survey data (Maxwell et al., 2014). These substantive codes emerged from engaging in *categorizing strategies*, such as examining similarities across survey questions, looking for common features, and comparing differences (Maxwell et al., 2014). As we developed the codes, we made sure to pay attention to the entire dataset rather than simply summarizing each question (see Braun et al., 2021), particularly since the survey was developed for course feedback rather than research purposes.

The next analysis step involved *connecting strategies* as we looked for contiguity relationships. Contiguity refers to the connection between ideas or concepts contextualized within a scenario; it includes influences and correlations (Maxwell et al., 2014). During this step in the analysis process, we began to display these cross-question relationships through a network, or visual map that illustrates the interconnections in a web-like, non-linear representation (Attride-Stirling, 2001; Maxwell & Miller, 2008). Our visual map enabled us to analyze contiguity relationships within the data.

As an example, we noted that during the outdoor experience, some students reported a sense of nostalgia or "feeling like a child again", a substantive category that emerged as we looked for similarities across the dataset. When we began searching for contiguity relationships, we contextualized this idea with a cluster of other responses–playfulness/joy–drawing connections between the two in light of the day's experiences. We visually connected these ideas within the web and discussed the association.

The entire process was *iterative* since we went back and forth between categorizing and connecting strategies throughout the analysis. It was also *discursive* because there

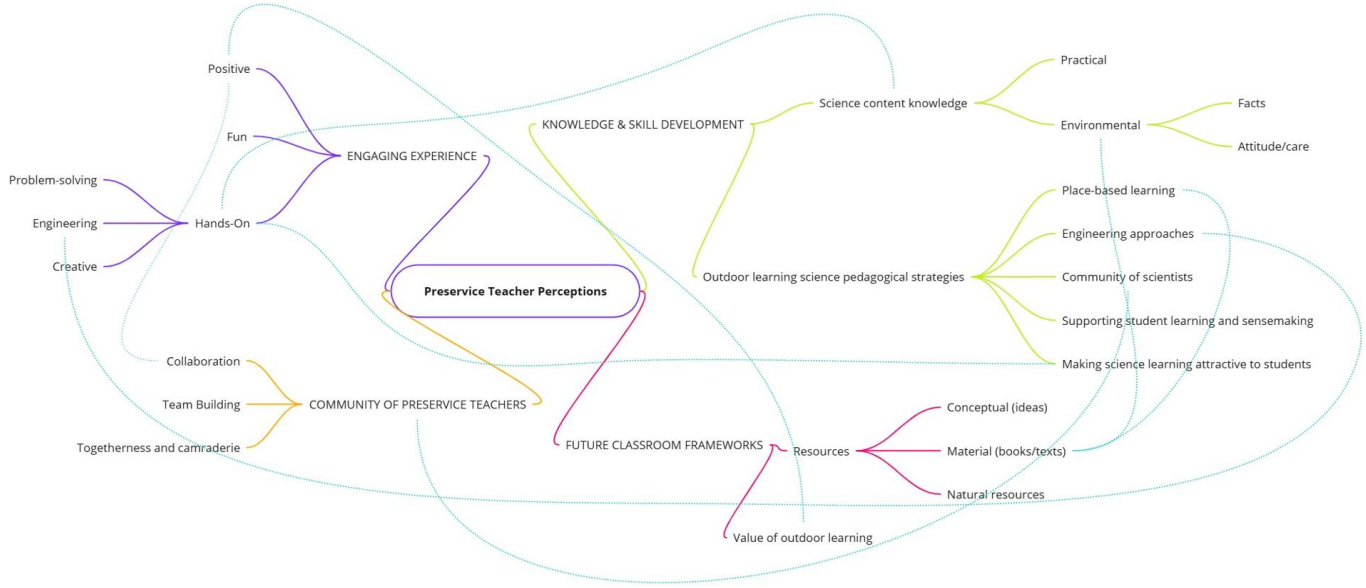

Figure 2. Network of key themes (Source: Authors' own elaboration)

were times in which we wandered in amongst the students' responses, often discussing one category before finding ways in which it could be contiguous with others (Braun et al., 2021). Although many patterns developed through our analysis, during step 4 we chose to focus on four themes that highlighted the broader context of the pre-service teachers' experience. These are illustrated in **Figure 2**.

Finally, we incorporated numbers as a way to "complement the participants' perspectives in providing a clearer and more in-depth understanding of what's going on in a particular setting" (Maxwell, 2010, p. 479). Numerical data were compiled and displayed as a way to enhance our qualitative findings during step 5.

Quality Considerations

We tended to quality criteria using Butler-Kisber's (2010) suggested six main issues of quality: trustworthiness, transferability, access and consent, reflexivity, voice, and transparency. Our goal was to remain ethical throughout the entire research process, seeing quality as an integral part of the research process rather than simply a check-list (Cho & Trent, 2006). We are transparent in acknowledging that this is a situated qualitative study and that the data are contextual, shaped in part by the fact that the survey questions were not originally designed for research purposes. While the exploratory nature of this work means the findings are not generalizable to other settings, we believe they are transferable and can meaningfully contribute to ongoing conversations in pre-service science teacher education.

FINDINGS

The data indicate that our pre-service teachers had a variety of perceptions regarding their outdoor learning experience, and key patterns and connections emerged within a network. Four themes–engaging experiences, a community of pre-service teachers, knowledge and skill development, and future classroom frameworks–were developed by exploring the contiguity relationships between codes. **Figure 3** uses numerical data to complement the qualitative findings related to the four themes, indicating both the number of times the ideas were represented within the survey responses as well as the percentage of participants who mentioned concepts related to each theme.

What are pre-service teachers' perceptions of a day-long outdoor learning experience within an early childhood science methods course?

Represented an Engaging Experience

Pre-service teachers overwhelmingly found the outdoor learning experience to be enjoyable, highlighting the fun, engaging atmosphere that came from learning in a natural setting. Hands-on activities were especially popular, with participants appreciating the opportunity to actively engage in an environment outside of the traditional classroom.

Positive and fun

Overall, our participants considered their outdoor experience to be positive and pleasant, commonly using words such as "fun" or "enjoy" to describe their methods class at the outdoor nature center. In considering both individual questions responses as well as connections between questions, it is evident that our pre-service teachers felt engaged throughout the class and also simply enjoyed the opportunity to be outside. A few students described how much they liked feeling "like a child again," illustrating how their positive feelings were closely connected to playfulness and joy. The data shows that integrating the outdoor setting, natural items, and structured learning was well-received by the pre-service teachers since the methods course instructors did not simply drag-and-drop a typical class into the outdoors. Maximizing the outdoor space and resources in a student-centered way was positively appreciated by participants.

It is important to note that a few students still experienced a bit of discomfort as reported in the survey. Some stated, "I did not like the cold," referring to the temperature in the morning, while others mentioned it was "too early" and "too

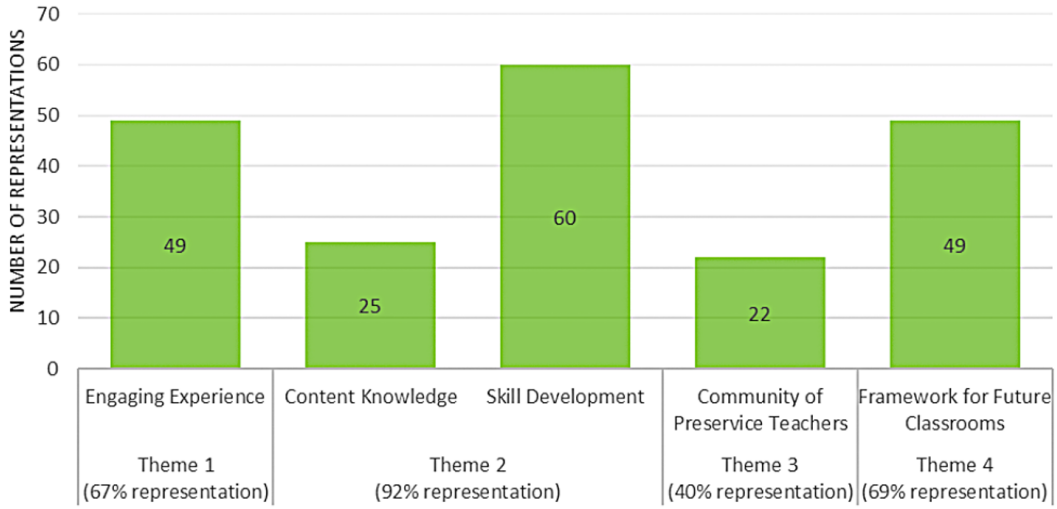

Figure 3. Graph of numerical data to enhance qualitative findings (Source: Authors' own elaboration)

long" of a class. Despite this feedback, the same participants had very positive things to say about the overall experience, listing specific components of the day that were particularly meaningful to them.

Hands-on engagement

The outdoor stations received the most positive feedback, and students expressed that they liked being outdoors doing hands-on activities that facilitated creative thinking and provided opportunities for kinesthetic learning. Some students explicitly stated the positive impact of this approach as their favorite part of the day:

> "I really enjoyed the centers a lot and how much I've learned from the hands-on activities."

Others were more implicit about what they enjoyed and why, such as "being active outdoors" or "trying new activities." The interactive nature of the class lent itself towards students being highly involved throughout the day. Furthermore, the hands-on component facilitated active participation by the students, and this sense of involvement contributed to the positive feedback and the overall enjoyable experience.

Contributed Towards Knowledge and Skill Development

This finding considers both the science content knowledge and pedagogical strategies that pre-service teachers gained through their participation in the outdoor learning experience. Participants reported learning specific scientific facts while also acquiring a variety of teaching strategies related to science and classroom management in outdoor settings.

Science content knowledge

Although the course instructor's intended purpose for outdoor experience was not to transmit scientific content, numerous participants reported that they learned specific facts related to scientific phenomena vis-a-vis the hands-on activities. These primarily revolved around two centers: the water filtration activity and the state environmental curriculum exploration. Some participants shared the scientific facts that they learned during the outdoor experience.

> "I learned about the landfill and how it works."

> "I learned that the marble fish tank rocks helped with water's alkaline level at the water filter center–loved it."

One student stated that she "loved being able to be the student," indicating an appreciation for taking on the role of a science learner. These participant quotes illustrate how many pre-service teachers had key takeaways pertaining to science content through participation in the various outdoor learning activities.

Outdoor learning science pedagogical strategies

Pre-service teachers who participated in the science methods outdoor experience reported a variety of pedagogical strategies that they gleaned from the day. This ranged from understanding of scientific skills to ways of supporting student sensemaking to exemplary models. Many of our participants reported that they learned a great deal about how to integrate science into an outdoor setting as well as other curricular connections, such as social studies. The students built up their *toolbox* of teaching strategies related to science as well as other general pedagogical and class management practices. For example, participants mentioned the importance of critical thinking skills related to the science and engineering challenges they tackled throughout the day. Additionally, many of the pre-service teachers described place-based scientific phenomena as a viable pedagogical strategy to engage young learners in outdoor science. This finding indicates that the outdoor learning experience had numerous perceived learning outcomes that went beyond what might typically occur within a traditional science methods classroom setting and were beneficial for pre-service teachers.

An idea that emerged across participants' discussions of both content learning and pedagogical strategies was the implicit presence of inquiry-based learning. While not always labeled as such, participants described activities that involved observation, exploration, asking questions, and problem-solving, which are all characteristics of authentic scientific inquiry. For example, several students referenced the

importance of hands-on exploration and critical thinking, while others described how the outdoor learning centers prompted them to "figure things out" or "be the student." These experiences modeled an inquiry-based approach to science teaching that many participants appeared to embrace, as evidenced by their stated intentions to foster similar learning environments in their future classrooms.

Built the Community of Pre-Service Teachers

During the outdoor learning experience, pre-service teachers reported feeling a strong sense of community with their fellow pre-service teacher peers. This experience fostered not only sentiments of togetherness but also collaboration, as participants engaged in hands-on science activities that encouraged critical thinking and problem-solving skills.

Feelings of togetherness

Across the survey data, participants acknowledged the impact of togetherness and the accompanying positive feelings. This experience included two separate cohorts of students who rarely interacted despite their similar status and progress within the program. One participant commented:

> "I really just liked the way we got to be outdoors and spend the day with people who we wouldn't always necessarily spend time with."

There was something novel about having the opportunity to interact with an entire group of their peers and learn within the community. One of the stations students attended focused on team-building, and our participants reported that they enjoyed the fun activities centered around the camaraderie. Although there wasn't a specific science focus at the team-building station, students made connections to their future classrooms and the importance for community. Working together with "ALL my friends" was enjoyable for our pre-service teachers, and many determined the importance of this togetherness within a future science classroom.

Collaboration

Participants appreciated the opportunities to collaborate both within their own cohort and with students from other cohorts. They expressed enjoyment in solving science-based problems with their peers, particularly during hands-on activities at the egg drop center and the water purification center. A common theme found in the analysis was the integration of "critical thinking skills" and "problem solving skills" within the collaborative outdoor science learning activities. One participant commented, "I enjoyed being creative and getting to collaborate with my classmates." Another reported that they learned "different ways to create communication between classmates" during the problem-solving process. These activities provided students with the opportunity to achieve success with their group members through the engineering design process and the development of scientific solutions contextualized within outdoor learning.

Some students clearly made connections between the collaboration they experienced at the outdoor nature center and their future classrooms. One individual shared how she looked forward to collaborating with colleagues in her teaching career as a way to authentically integrate science, the outdoors, and other subject areas. This highlights the importance of the outdoor learning experience in helping pre-service teachers understand the collaborative NOS learning and the positive effect of togetherness.

Impacted Frameworks for Future Classrooms

In examining pre-service teachers' perceptions of the outdoor learning experience, participants described the ways in which it influenced what they might enact in their future classrooms, including both their value of outdoor learning as well as their understanding of key resources.

Value of outdoor learning

"I will try to get my students to be outside as much as possible. There is so much value in the outdoors," one of our participants stated. This simple phrase highlights the overall feedback received about the importance of the outdoor environment as a setting for science learning. Students stated how they planned on teaching science outside when they became teachers, implementing outdoor centers or similar activities to what they saw modeled. The personal experiences of the pre-service teachers helped frame their appreciation of outdoor learning as integrated into science instruction. One participant stated:

> "I think that if integrated correctly, it could be something that really makes a positive and helpful impact."

Students realized that simply moving indoor science lessons into an outdoor setting wasn't as effective as integrating the natural environment into instruction. The science methods class at the nature center highlighted how *place* can be central to the learning and that natural materials–leaves, sticks, rocks, water–can play a key role within the scientific explorations. Students had significant takeaways related to the value of the outdoors and the importance of implementing outdoor learning with young scientists.

Understanding resources

Our pre-service teachers grew in their understanding of the resources available to them to support future careers implementing outdoor science learning. These resources were conceptual, material, and natural in nature. The conceptual resources consist of the ideas that the participants collected regarding ways to effectively integrate science into nature as well as other subjects. These ideas grew from the exemplary activities that the students experienced as well as from the time during the day to collaboratively design their own outdoor learning units or lessons. In the survey responses, there were quite a few instances where participants stated "I like the idea …" or "I want to try …" indicating that they have built up a repository of ideas as conceptual resources for their future classrooms. Additionally, students highlighted the material resources that they appreciated, such as the curriculum book to which they were introduced. Finally, our participants highlighted their newfound understanding of natural resources that were seamlessly integrated into the science learning activities. "I learned a lot about using the natural resources around me in order to create materials that can be useful in the real world," one student mentioned. Other

pre-service teachers hinted at this strong engineering component that was embedded into many of the science centers.

> I might try to come up with lessons like this in my future classroom to get outside and allow for my students to explore things in the natural environment to come up with solutions for different problems.

This participant quote highlights how the outdoor science methods class experience impacted both her understanding of resources for her future classroom as well as the overarching value of outdoor learning.

DISCUSSION

In this discussion, we examine how the four themes described above are intricately woven together within the context of the outdoor science methods class. While these themes were initially explored in isolation, their interconnectedness reveals a deeper understanding of how this immersive experience shaped the participants' learning and growth. By drawing on the framework of embodied cognition and connecting our findings to existing research, we highlight the complex ways in which these themes contributed to the pre-service teachers' development, providing a richer perspective on teacher preparation.

Connections to Existing Literature

Facilitating outdoor experiences within a science methods course can positively influence how pre-service teachers perceive outdoor learning for their future classrooms, recognizing that it is both accessible and effective in fostering a constructive interest in science. The engaging experiences that our pre-service teachers reported while participating in science instruction in a natural environment align with findings from other studies that examine the impact of outdoor learning within a methods course. For instance, Cevher Kalburan (2024) found that after completing a specialized course on outdoor learning methods, teachers increased both the quantity and quality of their outdoor teaching, adopting more hands-on, child-centered approaches. Furthermore, the literature indicates that positive outdoor experiences and a feeling of connection to nature can influence a pre-service teacher's intentions to take students outside to engage in outdoor learning (Blatt & Patrick, 2014; Ernst & Tornabene, 2011). Science education has an affective component, and feelings of joy, excitement, and success are an integral part of the scientific processes (Jaber & Hammer, 2016). However, teaching science outdoors can be challenging for early childhood or elementary teachers (Kerr, 2020) as is facilitating authentic inquiry-based investigations (Valls-Bautista, 2021). Granting opportunities for pre-service teachers to explore this pedagogical approach can be helpful towards future implementation by providing opportunities for pre-service teachers to experientially discover how the natural environment can align with inquiry-based science. The findings of this study align with Hawxwell's (2019) research, which suggests that incorporating outdoor learning into teacher education programs can address the concerns and anxieties pre-service teachers may have about this approach.

It was interesting to note that some students had on their "learner hat" during the survey response, embracing the science content they learned throughout the day, whereas others had on their "teacher hat" and were in-tune with pedagogical strategies related to outdoor learning (see Gunshenan et al., 2021). This suggests that the pre-service teachers had a variety of key takeaways from their firsthand experience, all of which seemed to contribute to their enjoyment of the class and/or their intention to implement outdoor learning in their future science classrooms. When educators take on the role of a science learner and engage in high-quality outdoor learning experiences, they can glean key science content, instructional strategies, and an overall value for learning in the outdoors (Carrier et al., 2023).

Connections Between Themes

Although presented separately, each of the four themes are interconnected and fit together to form a bigger picture of outdoor learning's potential for pre-service teachers learning how to teach science. As evidenced by our complex network of key themes portrayed in **Figure 2**, we uncovered many connections across our pre-service teacher's perceptions of the outdoor experience and will elaborate on some of the most salient relationships. First, the positivity and joy contributed towards participants' overall experience yet was also influenced by the other themes. Additionally, the sense of togetherness and collaboration lent itself towards a positive group experience that was enjoyable since it centered around community. Humans are social beings, and feeling connected within a community can increase one's overall sense of happiness and wellbeing (Cramer & Pawsey, 2023). The activities at the outdoor nature center facilitated collaboration which built community and influenced the positive feelings that our participants reported. By participating in collaborative activities, pre-service teachers can take part in a supportive community that improves their overall learning experience, preparing them for their future careers working with colleagues in schools. Feelings of togetherness fostered a sense of fun and enjoyment in the day, perhaps carrying over into future classes.

Another interconnection speaks to the highly applicable and interactive nature of the day's activities that lent itself to the positive experience our pre-service teachers had. For instance, participants were able to develop a useful framework for their future classrooms through personally taking part in science learning in an outdoor setting and interacting with ideas, various resources, and even natural materials. This aligns with other research that indicates that participating in outdoor science instruction can provide teachers with strategies to connect science to students' lives and the natural world (Carrier et al., 2023; Subramaniam, 2019). Pre-service teachers better understand the affordances of outdoor environments within science education by being exposed to a variety of places within their coursework that attend to pedagogical strategies (Ma & Green, 2021). In regard to our study, we infer that the impact of the methods class in the nature center experience was effective because it authentically integrated nature into each of the stations, required a hands-

on approach, and created space for our pre-service teachers to simply enjoy the benefits of being outside. Our research shows that, through outdoor learning, pre-service teachers gain knowledge and skills that are difficult to achieve in a traditional classroom setting, while also becoming joyfully engaged in the learning process.

Connections to Embodied Cognition Framework

In considering the embodied cognition framework, pre-service teachers learned through the interaction between their brain, body, and environment (see Fan, 2023; Ye, 2010). The physical space, including the landscape and natural materials, provided a context for the learning and contributed to the sensory experience that our participants had. All four key themes emerged from the embodied learning and activities that took place throughout the day. It was a *positive, engaging experience* because our participants were able to be active participants with the natural environment during the stations and independent journaling time. There was *knowledge and skill development* that represented the intersection between the physical materials, natural environment, and the participants' brains/bodies. The *community development* occurred throughout the day, but particularly through the station that centered active, physical movement to develop collaborative teamwork. Finally, pre-service teachers' frameworks for their future classrooms were a result of the situated nature of outdoor learning encapsulated within a natural, green space.

We posit that the pre-service teachers' perspectives towards outdoor learning would have been very different had the class been taught within the traditional indoor classroom. For instance, the physical act of manipulating the filter materials was an embodied experience and sensory interaction with the environment, connecting the learning into participants' brains (see Fugate et al., 2019). Abstract pedagogical concepts related to outdoor science learning became concrete in the physical space of the nature center. Cognitive activation strategies, such as prompting pre-service teachers to predict outcomes or explain the reasoning behind their actions, further deepened their engagement with the learning material. These strategies encouraged cognitive engagement, strengthening the pre-service teacher's ability to connect theory with practice (Baumert et al., 2017). As students' thinking became situated within physical experiences, their understanding and perceptions were shaped to value outdoor learning and appreciate specific pedagogical strategies. This suggests that outdoor learning in a science methods course can effectively embody learning for pre-service teachers, especially as it relates to science knowledge, skills, and accompanying teaching practices.

Teacher education programs still often lean towards a passive transmission of knowledge despite advances in neuroimaging that demonstrate the role of sensory and motor experiences within cognitive processing (Macrine & Fugate, 2022). This study on pre-service embodied experiences in an outdoor setting highlights one possible approach towards embracing the brain-body-environment connection within teacher education. If we want our pre-service teachers to engage their future students in high-quality science instruction that is authentic and hands-on, they need to see the possibilities of incorporating sensory-motor systems. Integrating the outdoors into these science experiences can lend itself towards embodied cognition in which students–both pre-service teachers and K-12 learners–physically experience a phenomena.

Considerations and Implications

The purpose of our exploratory study was to shed light on pre-service teacher perceptions of an outdoor learning experience. The findings are particularly significant for early childhood science education as they highlight the potential advantages of integrating outdoor experiences into teacher preparation programs. Our participants' survey responses point towards the impact that a single class can have on their development as pre-service teachers as well as their understanding of outdoor science teaching methods. We echo Blatt and Patrick's (2014) call from over a decade earlier that teacher education programs consider ways to create opportunities for pre-service teachers to engage with the outdoors as a way to facilitate positive connections to nature that carry over into classrooms. As younger generations shift away from frequent outdoor experiences during childhood (Louv, 2008), science methods instructors should consider ways to connect pre-service teachers to the outdoors while also modeling exemplary integration between nature and the NGSS.

We recognize that hosting a science methods class at an outdoor nature center requires logistical planning on behalf of the professors and may not be easily available for all teacher preparation programs. However, we suggest that simply incorporating outdoor instruction into science methods classes can serve as an easy yet meaningful first step given that regular outdoor teaching practice during initial teacher training can enhance pre-service teachers' self-confidence and self-efficacy (Wolf et al., 2022). Similarly, Semiz and Temiz (2021) found that engaging in diverse activities with natural materials and environments boosted pre-service teachers' confidence in nature-based teaching. The overall positive effect reported by pre-service teachers indicates that an outdoor experience embedded within a science methods coursework can effectively develop their skills and framework for the integration of outdoor learning and science education.

The survey was initially designed to gather student feedback on the experience, rather than to serve as a formal research instrument. Patton (2015) emphasizes the value of *naturalistic data* not necessarily designed for research in that it can still contribute towards an understanding of lived experiences. As such, we intentionally don't claim causality or broad generalizability regarding the findings, acknowledging that the survey questions may present a limitation to the study. For instance, one question, "What did you like the best about today's experience?" could be perceived as leading. However, it is important to note that the survey also included a question about what students liked *least* about the experience, and participants were always given the option to refrain from answering. To address these limitations, future research should aim to explore the impact of outdoor science education on pre-service teachers using a more structured survey or alternative data collection methods.

Despite the immersive nature of the pre-service teachers' outdoor experience, it took place within a class that lasted only

six hours. While some studies suggest that short-term outdoor experiences can still be impactful, a longer-term engagement across a semester may deepen learning and enhance transformative potential (Braun & Dierkes, 2017; Rickinson et al., 2004). Future research should therefore explore the possibilities of providing pre-service teachers with more sustained exposure to outdoor learning environments in science methods courses.

CONCLUDING THOUGHTS

This exploratory study underscores the potential of outdoor learning experiences embedded within science methods coursework for pre-service teachers. By integrating hands-on, engaging activities in a natural setting, the experience not only enhanced participants' knowledge and skills but also fostered a sense of community and an appreciation for outdoor learning's pedagogical value. These findings highlight the importance of providing pre-service teachers with opportunities to engage in experiential and embodied learning, which connects cognitive processes to sensory and physical interactions with the environment. Moreover, this research contributes to the growing recognition of outdoor learning as a means to address challenges in early childhood science education. The positive perceptions reported by participants affirm that thoughtfully designed outdoor experiences can serve as a powerful tool to build pre-service teachers' confidence and readiness to implement NGSS-aligned science instruction in diverse settings. The understanding gleaned from this work will interest a variety of science education stakeholders, expanding the broader field of K-12 science education, science teacher education, and related research. Through this study, we envision a path forward where outdoor learning becomes an integral component of science education, empowering both pre- and inservice teachers to deliver engaging, authentic lessons that cultivate curiosity and foster scientific literacy in young learners.

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AI statement: The authors stated that ChatGPT was used occasionally to enhance the clarity of English language in some sentences. Grammarly was used for proofreading.

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APPENDIX A

Note. Students had the option to skip questions or write N/A.

Participant Reflection Questions

1. What did you learn today?
2. What did you like best about today's experience?
3. What did you like least about today's experience?
4. What might you try in your future classroom?
5. Which center or rotation was your favorite, and why?
6. Next year, where should we have this integrated class?
7. Is there anything else that would be helpful for us to know?