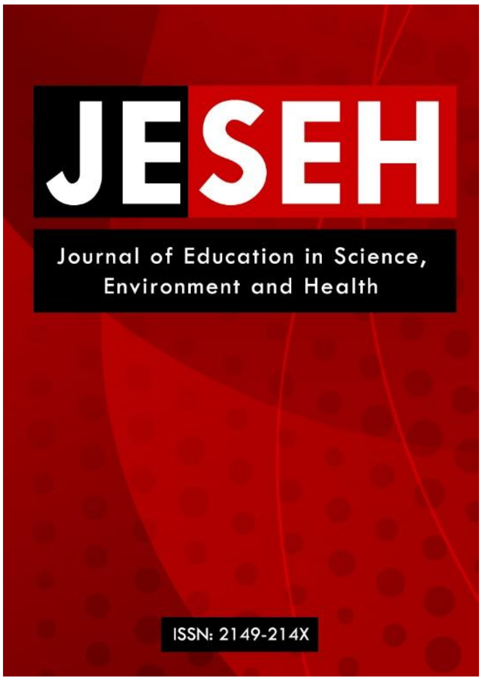

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Exploring Elementary Preservice Teachers' Nature Investigations

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Abstract

The shift to online instruction during the COVID-19 pandemic posed significant challenges for engaging preservice teachers in authentic, inquiry-based science learning. To address these challenges, place-based and inquiry-driven investigations emerged as promising strategies for supporting meaningful scientific engagement in remote settings.This study aims to explore elementary preservice teachers' (PTs) inquiry-based nature investigations and their reflections on their perceptions of the experience. The participants of the study included 38 PTs in the context of a science laboratory course in an elementary education program at a public university in Turkey. Data sources included PTs' inquiry reports and reflections and were analyzed for inquiry coherence and their perceptions of the nature experience. Findings showed varying levels of inquiry engagements, from fully coherent investigations with clear research questions and explanations to minimal engagement with purely descriptive observations lacking inquiry focus. In addition, PTs reflected on the advantages of nature investigation, including increased biodiversity knowledge, awareness, and a deeper connection to the environment, as well as the affordances of mobile applications. Based on the findings, implications for teacher education are discussed.

Introduction

The global shift to online instruction caused by the COVID-19 pandemic created many challenges in maintaining practical and interactive science education (Avsar - Erumit et al., 2021; Bakioğlu & Çevik, 2020; Barton, 2020; Sahu, 2020; Ünal & Bulunuz, 2020). During this time, elementary preservice teachers (PTs) also struggled to engage in scientific inquiry (Avsar- Erumit et al., 2021). For PTs to improve their science teaching practices, their own engagement in inquiry-based learning as students is crucial (Windschitl, 2003).

In addition to inquiry skills, biodiversity knowledge is important for effective science teaching. Many PTs enter teacher education programs with limited experience with species identification (Kassas, 2002; Saunders, 2003), a gap compounded by a lack of biodiversity topics in standard teacher education programs (Bebbington, 2005; Hooykaas et al., 2019). Addressing this gap is important, especially in the elementary science curriculum, which emphasizes understanding living and non-living organisms. Using place-based learning became difficult to implement in online settings despite its reputation for fostering environmental awareness and confidence in teaching science (Carrier, 2009; Trauth-Nare, 2015). Enhancing PTs' biodiversity content knowledge could help them teach these concepts more effectively in their future classrooms. However, few studies explored how mobile applications in place-based learning can bridge this gap in remote teacher education contexts.

Mobile applications provide a unique opportunity for nature investigations, enabling PTs to explore biodiversity independently through real-time access to databases and visual resources (Chen et al., 2008). While previous studies have explored place-based and inquiry-based learning separately, few have examined how mobile applications can mediate place-based biodiversity investigations in an online teacher education context. This study addresses this gap by integrating mobile technology into online learning to enhance PTs' inquiry skills, local biodiversity knowledge, and environmental awareness. Improving PTs' biodiversity knowledge and inquiry skills is crucial not only for their own academic development but also for their future role as educators who can foster environmental literacy among elementary students. This study aims to contribute to this goal by examining how mobile application-facilitated nature investigations support PTs in developing coherent inquiry investigations and what their perceptions of this experience are in an online context. Specifically, it addresses the following research questions:

1. To what extent did PTs develop coherent inquiry-based nature investigations?
2. How did PTs reflect on their observations, noticings, and use of mobile applications during the nature investigation process in an online setting?

Conceptual Framework: Place-Based and Inquiry-Based Learning

This study is guided by place-based and inquiry-based learning approaches. Place-based education leverages local environments for learning, encouraging students to engage with their surroundings as sites of investigation (Sobel, 2004). By grounding learning in local contexts, place-based education enhances relevance, engagement, and cross-disciplinary understanding, supporting academic success (Semken & Freeman, 2008; Sobel, 2005). This approach centers on students' questions and interests, connecting their curiosities to their daily experiences to make learning more meaningful. In this study, PTs examined their local environments and developed research questions for investigation. Research shows that place-based education promotes experiential, participatory learning, improving understanding and academic outcomes (Ballantyne & Packer, 2009; Semken & Freeman, 2008). It emphasizes spatial, embodied, and contextual learning, allowing students to gain hands-on experience with natural or human-made environments (Semken et al., 2017). Through direct engagement with local sites, students apply skills and concepts in real-world contexts, deepening their understanding of environmental processes and their impacts (Sobel, 2004).

Inquiry-based learning involves engaging students in scientific investigations to make predictions, collect and analyze data, and develop evidence-based explanations (NRC, 2000). Engaging PTs in inquiry-based learning fosters essential skills as learners of science (Stuchlikova et al., 2013; Weld & Funk, 2005). Local environments provide authentic contexts for inquiry, aligning place-based pedagogy with inquiry-based learning to create meaningful and relevant investigations (Anderson, 2011; Brown, 2021). Research supports the efficacy of place-based education in teaching environmental education (Buxton, 2010; Meichtry & Smith, 2007; Semken, 2005; Sobel, 2005).

Many PTs enter teacher education programs with limited exposure to inquiry-based learning (Windschitl, 2003). Given these gaps, place-based education offers an ideal approach for addressing PTs' limited biodiversity knowledge by immersing them in local ecosystems, fostering direct interaction with diverse species and ecological processes. In this study, place-based learning provided the contextual foundation for PTs to engage with their local environments, while inquiry-based learning guided the process of formulating questions, collecting data, and analyzing findings. Mobile applications functioned as a mediating tool for species identification and supporting data collection and analysis. This study integrates place-based and inquiry-based approaches to provide PTs with meaningful investigations, fostering scientific skills and content knowledge in an online learning environment.

Background to the Problem

Challenges and Urgency in Biodiversity Education

Human activities such as greenhouse gas emissions, pollution, and habitat destruction have caused a biodiversity crisis, with up to one million species at risk of extinction (Hooper et al., 2005; IPBES, 2019). Thus, this situation requires teachers to equip future generations with knowledge of biodiversity and conservation. Biodiversity literacy is, therefore, a foundational element of environmental education and aligns with the United Nations' 2030 Agenda for Sustainable Development, especially Goal 15 (SDG 15), which focuses on halting biodiversity loss and promoting sustainable ecosystems (UN General Assembly, 2015).

Schools can play an important role in biodiversity learning through experiential and place-based learning opportunities. Observing species or conducting nature-based investigations can facilitate deep connections for students to their surrounding ecosystem (Bögeholz, 2006; Louv, 2006). Nature investigations are known to encourage positive attitudes toward conservation (Nelson et al., 2016) and to enhance overall well-being (Chawla, 2015; Gill, 2014). However, research shows that children are spending less time in nature (Louv, 2016; Soga & Gaston, 2016), leaving teachers with an increased responsibility to reconnect them with their environment. In this context, to develop students' environmental awareness, teachers need strong biodiversity knowledge and a positive attitude towards nature (Skarstein & Skarstein, 2020; Wolff & Skarstein, 2020).

Challenges in Species Identification

Research shows that PTs have difficulty in identifying species due to limited experience, insufficient training, and difficulty accessing accurate resources (Melis et al., 2021; Kurniawan, Tapilow, & Hidayat, 2017). For example, Kurniawan et al. (2017) found that limited online resources hindered the identification of bird species during field trips. Moreover, although PTs have positive attitudes toward biodiversity, their knowledge and confidence are often insufficient (Harman & Yenikalayci, 2020; Ozdemir, 2020; Melis et al., 2021).

Research shows that strengthening PTs' species identification skills increases their ability to effectively teach biodiversity (Kaasinen, 2019; Lindemann-Matthies et al., 2011; Palmberg et al., 2015). For example, Palmberg et al. (2015) found that while PTs recognize species knowledge as essential for sustainable development, they often focus on pragmatic properties (e.g., edibility or toxicity) rather than the ecological importance of the species. Kvammen and Munkebye (2018) demonstrated that targeted training improved PTs' identification skills but highlighted the need for sustained approaches to retain this knowledge in teacher education.

Research advocates for integrating biodiversity education into core curricula (Bulut & Beşoluk, 2019; Yüce & Doğru, 2018). One way to incorporate this into the curriculum would be to combine inquiry-based and place-based approaches to address these gaps in teacher education. For example, Skarstein and Skarstein (2020) found that inquiry-based species identification activities improved PTs' knowledge and confidence and helped them apply this knowledge during their teaching practice. However, the implementation of place-based inquiry investigations in online learning contexts remains challenging.

Potential of Mobile Applications in Environmental Education

Previous research has shown that mobile technologies, including smartphones and tablets, offer flexible, interactive tools for biodiversity education, enabling real-time data collection and species identification (Huang, Lin, & Cheng, 2010; Rogers et al., 2005; Sung, Chang, & Liu, 2016). In biodiversity education, traditionally, tools like dichotomous keys and printed guides have been used for species identification (Andic et al., 2019; Stagg & Donkin, 2013), but mobile applications provide enhanced functionality by integrating multimedia resources and taxonomic databases (Chen et al., 2008).

Mobile applications allow users to identify organisms using automated software, expert feedback, and extensive databases (Nugent, 2018; Zydney & Warner, 2016). For example, the iNaturalist app was used in identifying marine organisms (Michonneau & Paulay, 2015), birds (Thomas & Fellowes, 2017), reptiles (Whittmann et al., 2019) and mammals (Fraser et al., 2019). These applications bridge gaps in PTs' species identification skills (Nugent, 2018; France et al., 2016).

This study integrates mobile applications to address the challenges of remote, place-based, inquiry-based science learning during the COVID-19 pandemic. PTs were introduced to applications such as Google Lens, Inaturalist, Plantnet, and Plantsnap to conduct nature investigations in their local environments. By leveraging mobile technologies, this study aims to enhance PTs' biodiversity knowledge, inquiry skills, and environmental awareness within a remote learning environment.

Method

Research Methods and Context

This qualitative study used a naturalistic inquiry approach (Lincoln & Guba, 1985) to explore preservice elementary teachers' (PTs) engagement with nature investigations in an online learning environment. Naturalistic inquiry was used as it allowed for an in-depth exploration of PTs' experiences and reflections in the learning environment, focusing on how they engaged with nature investigation in their chosen places. The context of the study is a sophomore-level science laboratory course within the elementary education program. In this program, PTs complete two science content courses (general science and environmental science) in their first year, a science laboratory course in their second year, and a science teaching methods course in their third year. The science laboratory course, central to this study, is a mandatory, hands-on course taught over 15 weeks, with two hours of weekly instruction. PTs engaged in inquiry-based investigations using scientific practices coupled with theoretical knowledge. Instruction followed constructivist models such as the 5E Instructional Model (Bybee, 2015), the Predict-Observe-Explain (POE) model, and argumentation techniques, with PTs documenting their work in science notebooks.

Traditionally taught in person, the course shifted to an online format due to pandemic restrictions, necessitating adjustments to the main interactive and practical learning. PTs engaged in various inquiry-based investigations, documenting their observations and reflections in digital science notebooks, supported by Google Classroom. The course emphasized authentic scientific practices, requiring PTs to design experiments, make predictions, collect data, and construct evidence-based explanations. The nature investigation became a crucial component of the course, providing PTs with opportunities for field-based learning despite the online format. The nature investigation conducted post-midterm lasted three weeks: two weeks for observations and one week for report writing and presentations. Other investigations during the course covered diverse topics, including simple circuits, states of matter, seed germination, and nature observations. While most investigations spanned one week (e.g., electrical circuits), some (e.g., seed investigation) extended over multiple weeks. The course was taught synchronously online.

Participants

This qualitative study involved 38 (27 Female, 11 Male) elementary PTs from a public university in southwestern Türkiye, selected through convenience sampling. The class included 50 PTs, of whom 38 submitted reflection and inquiry reports; these 38 PTs formed the study's participant data set. Written informed consent was obtained from all participants, and the study received institutional review board approval before collecting data from Aydin Adnan Menderes University Educational Research Ethics Committee, with the decision dated August 6, 2021 (Session No: 18, Decision No: III). To ensure confidentiality, pseudonyms were used for all participant names in the data and reporting.

Data Collection Tools

Data consisted of 38 digital inquiry investigation reports and 38 written reflections. The reports included investigation questions, a description of data collection sites, collected data through photographs and videos, and evidence-based explanations of observations. For reflections, PTs were prompted with the following open-ended questions: "What were your thoughts on nature observation? What were the advantages and disadvantages of this experience for you? What did you notice during this process? Which mobile applications did you use, and how was your experience using them?" In the nature investigation, we discussed how scientists classify living organisms and the importance of PTs' understanding of the characteristics of living and nonliving things, as emphasized in the human and environmental unit of the primary school curriculum (MoNE, 2018). PTs were guided to develop observational skills and prepare to address future students' questions about species and nature.

Due to the pandemic, PTs conducted observations in their local environments. I guided PTs through modeling a nature investigation activity with children in a nearby park, sharing our experiences and observations of plants, trees, and animals with photos. A YouTube video (The Wonder of Science, 2018) was used to demonstrate techniques for exploring microhabitats to see species under logs, emphasizing respect for nature and small animals. Then, PTs were introduced to mobile identification apps, including iNaturalist (https://www.inaturalist.org), PlantSnap (https://www.plantsnap.com/), PlantNet (https://apps.apple.com/us/app/plantnet/id600547573), and Google Lens (https://lens.google/), which offer real-time identification and user-contributed databases. These tools were demonstrated to discuss species and illustrate how technology can support observation and inquiry. Then, I shared the types of questions children asked during our nature observations to illustrate how nature observations can spark curiosity and inquiry. I emphasized the importance of questioning as a scientific practice and that all inquiry investigations begin with a research question.

PTs were encouraged to choose local environments (e.g., parks, forests, fields, gardens) for observations, documenting findings through videos or photos. While identification targets were not specified, PTs were asked to freely observe and identify plants, animals, and other natural elements. Videos were recommended for richer accounts and easy sharing during synchronous online sessions. Some PTs faced challenges during the first week due to COVID-related restrictions, so an additional week was provided. After two weeks of observations, PTs submitted digital reports, including videos, photographs, and descriptions. The following week, PTs presented their findings using the collected media in the online class.

Data Analysis

The reports were analyzed using content analysis, guided by a rubric adapted from Plummer and Tanis Ozcelik (2015), originally designed to analyze PTs' lesson plans in astronomy inquiry investigations. The adapted rubric is used to evaluate the coherence of PTs' investigations using four key criteria, as shown in Table 1: the presence of an investigation question, the data collection process, the connection between the collected data and the investigation question, and the quality of evidence-based explanations. Each report was categorized into one of the four levels, as shown in Table 1.

Table 1. Rubric for analyzing inquiry reports

Level of Coherence in Inquiry	Level 1	Level 2	Level 3	Level 4
Is there an investigation question?	There is a clearly stated, and focused investigation question.	There is a clearly stated, and focused investigation question.	There is an investigation question.	There is no investigation question or statement.
Is there a data collection process?	Observational data is collected and presented through videos or photographs.	Observational data is collected and presented through videos or photographs.	Observational data is collected and presented through videos or photographs.	Observational data is collected and presented through videos or photographs.
Is Data and the investigation question connected?	The collected data is directly connected/aligned to the investigation question.	The collected data is connected to the investigation.	The collected data is not connected to the investigation question or there is limited connection due to the question being broad.	Not applicable, as there is no question.
Is there an explanation?	The explanation is evidence-based and connected, and directly answers investigation question.	The explanation is present, but the connection between evidence and explanation is implied, or limited in detail.	The explanation is not in response to the question. Or there is only a description of observations.	There is no explanation, only observational notes, or descriptions of what they did are provided.

The rubric was adapted to reflect the context of this study. The original rubric featured four levels (Levels 1, 2, 3, and 4). I used the same levels but slightly changed the level 3 description. Levels 1, 2, and 4 remained the same as the original rubric. In the original Level 3, there was an investigation question and data collection in response, but no explanation aligned with the question. In the adapted version, level 3 includes an investigation question, with observational data collected. However, either the data and research question were not connected, or the question was too broad, leading to an unfocused investigation. Thus, the collected data is not connected to the investigation question, or the explanation does not address the question. Reports were systematically assessed across these levels, allowing for a structured evaluation of coherence in PTs' inquiry practices. While Level 1 reports demonstrated the highest level of coherence in inquiry engagement, Level 4 reports showed minimal coherence.

Reflections were analyzed using thematic analysis (Braun & Clarke, 2006). Responses to the first three prompts were combined due to overlapping themes, while the last prompt was analyzed separately. I began by reading through all the reflections to gain an initial sense of the content. Next, I conducted open coding to identify emergent codes directly from the data without predetermined categories. Iterative, open coding is followed by grouping similar codes into broader categories. The coding framework is provided in the Supplementary material. Two researchers independently coded a subset of reflections to ensure consistency, resolving discrepancies through discussion. Final coding schemes were applied to all data.

Results

Results from Written Reports

The analysis of PTs' written reports revealed a variety of nature investigations conducted in diverse settings, including gardens, jogging tracks, and community parks in urban areas, as well as fields and gardens in rural areas, depending on where PTs resided. All reports included observational data supported by photographs or videos, though not all contained investigation questions or detailed explanations. In their videos, PTs often examined insects under logs, plants, trees, and animals, frequently expressing uncertainty about species names and resorting to general terms like “flowers,” “trees,” and “insects.” However, in their written reports, many PTs identified local plant names and often provided species and family names, indicating additional research on specific organisms.

Among the 38 reports analyzed, PTs showed varying degrees of inquiry engagement. Reports were classified into four coherence levels, ranging from fully integrated inquiry process (level 1) to minimal inquiry engagement (level 4). The majority of PTs’ reports (58 %, 22 PTs) were classified as Level 1, which included a clear investigation question, data collection aligned with the question, and connected evidence-based explanations. For example, Dilek posed the research question, “What are the names of the plants in my environment and which family do they belong to?” She documented her observations through videos and included screenshots from the inaturalist app (Figure 1), identifying species such as castor oil plant, Nerium oleander, and Clovers.

Figure 1. Dilek’s data shows a screenshot of the inaturalist app she put in her report

She explained: “The castor oil plant (Ricinus communis) is a species from the Euphorbiaceae family, native to India. It grows naturally or is cultivated in regions with a Mediterranean climate. The seeds contain a toxic substance called ricin.”

Level 2 reports (11%, 4 PTs) included a clear investigation question and connected data but offered limited or implied explanations. For instance, Furkan asked, is it possible for us to observe any underground organisms that live near the surface in our local environment? What can we see as the structures that animals use as nests? as research questions. He added a video showing ants and beetles under logs, along with observational notes The place where I conducted my observation was our garden. There are trees and many types of animals typically found in natural environments. During my observation, I came across ants and two beetles of the same species but in different colors. I also observed an ants’ nest in the area where the ants were active.

Figure 2. Screenshot from furkan’s video data showing animals under the logs

His explanation included: “Overall, we observed animals, their habitats, plants around us, and a form of life that isn’t easily noticed. After examining these, we researched the names of the animals we saw and found that one was called the Golden Beetle.” While his observation was linked to the research question, his explanation lacked depth and a clear connection to the research question.

Level 3 reports (13%, 4 PTs) featured an investigation question and collected data but lacked a strong connection between the two or posed overly broad questions, leading to an unfocused investigation. For example, Tuana posed, “Why do trees shed their leaves as the seasons change?” Her report included descriptive observations like leaves on the ground, tree colors, and the presence of animals. These observations were largely descriptive and focused on general surroundings but failed to directly address the research question.


Figure 3. Tuana's photographs in her data

Her explanation highlighted her observations:

The ground was covered with fallen leaves. The leaves on the trees were shades of orange. The surroundings were quiet. The animals were hungry and came close to us for food. The weather was beautiful. The clouds were scattered, but the view was extraordinarily beautiful. Some of her observations were connected to her posed question, however, the observations were descriptive. The question required a causal explanation rather than observational data, further limiting the coherence of her investigation. Level 4 (21%, 8 PTs) reports demonstrated minimal inquiry engagement, lacking an investigation question and formal explanations. For example, Ruya provided rich observational descriptions but no investigation question or explanation. She wrote:

The coexistence of plants and animals to beautify nature was wonderful to see. I observed how worms aerate the soil underground to sustain life and how fallen leaves decompose, enriching the soil. I also saw decaying fruits on the ground used as food by animals; here, I observed a quince fruit. I noticed how other animals fed on the body of a pigeon after it had fallen to the ground. Worms especially caught my interest; they create channels to allow air and water to reach deep into the soil, which is beneficial for plant roots. Ivy-like plants wrap around the nearest plant to reach sunlight. The ivy I observed was the bottle gourd plant. It has a hard outer shell with a unique liquid inside and is used for decoration or storing and serving food. The fact that the olive tree didn't shed its leaves, even in winter, shows it is an evergreen tree. Other trees like mulberry, walnut, and fig had their leaves turn yellow and fall. I couldn't identify the plant in the second image, but I observed that it had hair-like thorns, possibly to protect itself from the cold.


Figure 4. Ruya's photographs in her data

While her observations (e.g., interactions among plants and animals, seasonal changes in vegetation, and environmental features, the role of worms in aerating soil, or the ivy climbing for sunlight) were rich and detailed, the report included no guiding questions or explanation, leaving the report observational rather than inquiry based. These findings reflect a spectrum of inquiry engagement among PTs, ranging from a fully coherent inquiry process to observational descriptions without inquiry focus. While many PTs successfully structured their reports with clear research questions and evidence-based explanations (Levels 1 and 2), others struggled to connect observations to their questions or lacked a guiding question entirely (Levels 3 and 4).

Reflections on Nature Investigation

The analysis of PTs' reflections on their nature investigation revealed eight themes represented in Figure 5: science and technological knowledge gain, improved awareness about biodiversity and ecological changes, opportunities for investigation and detailed observations, positive ideas, awareness about attentiveness and knowledge levels, fear-related concerns, environmental and physical discomfort, and holistic well-being.

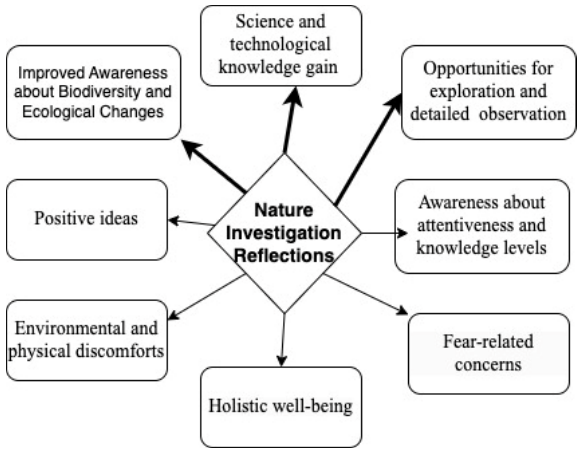

Figure 5. PTs' reflections on nature investigation

The first theme, science and technological knowledge gain, highlighted PTs' increased understanding of plant and animal species and their habitats. Many PTs noted that the investigation allowed them to learn about species' characteristics and their benefits to nature and humanity. For instance, Yener shared: "I learned that plant species from various regions can grow in different geographies. For example, Washingtonia robusta, native to Mexico, is also found in parks in Aydın [in Turkey]". Similarly, Melek wrote:

"I learned about living things that never caught my attention in nature. I discovered which group they belong to, where they grow, and their benefits. These observations showed me the transformations and formations in nature. I realized that many overlooked organisms have remarkable properties".

In addition to increased conceptual knowledge, PTs reported enhanced technological skills using mobile applications. Attila noted, "We can learn the names of almost all plant species quickly through mobile applications." These reflections emphasize how the nature investigation improved PTs' science and technological knowledge.

The second theme includes PTs' developing awareness of biodiversity, ecological changes, and the richness of their local environments. They reflected on the habitats, benefits, and interconnectedness of living organisms, as well as seasonal shifts. Sena observed, "I realized that the plants we see in our daily life are very important. For example, I learned that the sycamore tree absorbs polluted air." Seasonal changes also stood out to PTs. Atlas remarked, "Pine trees remain the same in summer and winter, and even in winter, they give cones. I observed maple trees shedding leaves at different rates and acacia seeds varying between trees." PTs expressed surprise at the diversity in their local environments. Zehra appreciated unique plants in the Aegean Region, while Melis shared, "The chicken varieties I saw surprised me. I never thought there was such a variety of animals on Earth." Melek noted a shift in perspective, saying, "Plants plucked and thrown away as harmful or useless in our garden have many benefits and are consumed in other cities. I now better understand the biodiversity value of my city." These reflections focused on the effect of nature investigation on raising environmental awareness among PTs.

The third theme, opportunities for exploration and detailed observation, emphasized how the activity encouraged PTs to make detailed observations and explore their surroundings. For example, Yasmin noted, "Nature investigation has made me observe nature better. I learned what lives with us, where, and how they live". Havin added, "This experience allowed us to see plant and animal species that we cannot see without examining them." Several PTs also reflected on the lasting value of this experience, suggesting it sparked ongoing interest: "I'm thinking of observing my surroundings more carefully and keeping a notebook for it" (Ferhan). Kevser also shared, "From now on, I will look around more carefully, research organisms that I do not know, and share this knowledge with others or my future students." These reflections demonstrate how nature investigation fosters a deeper connection to the environment, promoting curiosity and continuous inquiry.

The fourth theme, positive experiences, reflected the beneficial nature of the investigation. PTs described it as fun, motivating, and engaging. For example, Mehtap noted, "Being aware of the organisms around us was a beneficial experience," while Ilayda highlighted, "In this quarantine period and after the exam week, it was very motivating to discover the garden in nature. It was a nice, fun, and useful experience". These reflections suggest that such activities can enhance learning engagement even during challenging times like the pandemic.

The fifth theme, awareness about attentiveness and knowledge levels, showed PTs' developing self-awareness regarding their attentiveness to nature, knowledge gaps, and environmental responsibilities. Many reflected on how often they overlook their surroundings. Sena noted, "I realized how many plants and animals there are in nature that we do not pay attention to." Several PTs reflected on the decline of curiosity over time. Kevser shared, "As children, we wonder about everything around us and ask questions. As we grow older, we lose that curiosity. I realized I hadn't examined plants or my environment in such detail for a long time." Some participants acknowledged their limited knowledge about nature. Suna admitted, "I realized I had never had such deep knowledge about living things." Similarly, Zehra reflected, "I realized I did not know the names of many plants—I used to just say 'Flower.' Today, I learned the names of the plants I observed." A few PTs also expressed an increased sense of environmental responsibility. Zehra noted, "I realized once again that as humans, instead of protecting plants and animals, we pollute the environment and harm them in this way." These reflections highlighted not only heightened awareness and curiosity but also a recognition of knowledge gaps and a deeper sense of responsibility toward the environment.

Despite the positive outcomes, some PTs also wrote fear-related concerns and environmental discomfort, reflecting challenges they encountered during the activity. For example, Yasmin noted, "The disadvantage was examining the stink bug, the insect I feared the most." Similarly, Ipek added, "It is a disadvantage for me to carry out environmental research in a limited area due to the current pandemic and my fear of insects." Others faced difficulties with weather, muddy conditions, sticky substances, allergies, or seasonal limitations. For example, Havin wrote, "I had some difficulty entering muddy places and discovering organisms living there." Similarly, Sevgi stated, "The weather was very cold, and the ground was moist because of the rain. I couldn't explore much because of the virus." These reactions reveal logistical and personal challenges PTs faced during nature investigation.

The final theme, holistic well-being, showed how nature investigation supported PTs' self-care, stress relief, and motivation, particularly during the COVID-19 lockdowns. For example, Nil shared, "It [the experience] was both educational and enjoyable. We were able to devote a few hours of our day to ourselves and focus on good things." Tuba noted, "Going for a walk in nature relieves stress. At that moment, I only focused on the new organisms and plants I noticed, examining their movements. This was very beautiful." These reflections show the effects of incorporating nature-based activities into educational programs for their potential to enhance emotional well-being.

Reflections on the Use of Mobile Applications

PTs' reflections on the use of mobile applications to identify organisms during their nature investigation, categorized in Figure 6, highlighted three main themes: the used mobile applications, the affordances of mobile applications, and their shortcomings. Their responses revealed diverse usage patterns: some PTs used a single application, others used two simultaneously, and a few opted not to use any application but rather sought help from knowledgeable individuals. Among the 38 PTs, the majority (20 PTs) used Google Lens. Other applications included iNaturalist (10 PTs), PlantSnap (9 PTs), and PlantNet (9 PTs). Additionally, four PTs consulted knowledgeable individuals instead of apps. For example, Ata used the PlantNet: "I used the PlantNet mobile app. I realized that the application analyzes not only leaves but also flowers and stems of the plant." Melih combined Google Lens and PlantSnap: "I used Plantsnap and Google Lens applications. Google Lens was an application I used before, but I used Plantsnap for the first time". Some PTs relied on personal networks for identification. For example, Sena wrote, "I asked my friend, who is a landscape architect. I did not use any application, but I did a Google search to confirm its accuracy". Similarly, Fazilet explained, "I did not use any application; I asked my mother for the names of the plants, then after verifying it on the internet, I continued to search by the plant name."

Most PTs emphasized the benefits of using mobile applications, describing them as quick, accessible, and effective tools for learning. Buse noted the simplicity of learning with PlantSnap: "The Plantsnap app makes it easy to learn about plants. I always believed that it is very difficult to know the types of trees and plants. This app makes it easy. I will always use it." Selim appreciated Google Lens for its practicality: "I used the Google Lens application.

When I took a photo of the plant, it helped me find the information practically. It allowed me to access information quickly".

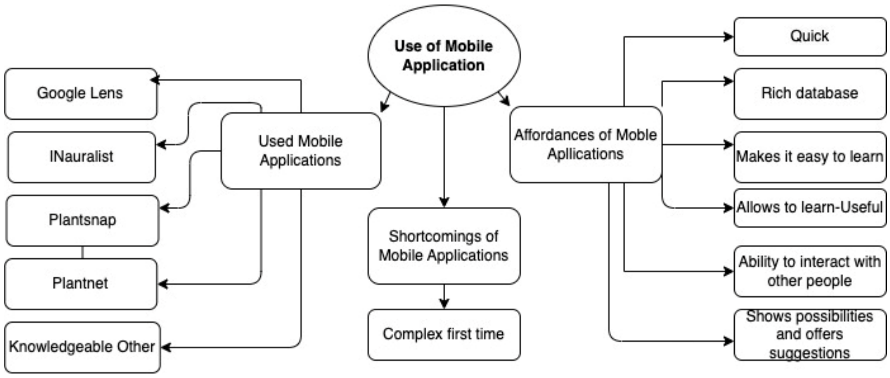

Figure 6. PTs' use of mobile applications

Other PTs valued the richness and interactive features of iNaturalist. Dilek shared, "I did my research with the iNaturalist app. The app gave more than what I was looking for. It was a nice feature that people can interact and comment within the app." Ipek added, "I used the iNaturalist mobile application. It shows similar results quickly, contains many species, and offers suggestions." Havin emphasized iNaturalist's social features: "It was a different feeling for me to get different views and have different audiences see the pictures I took. The app gave suggestions for the plant family and detailed characteristics of the plants".

While most PTs found the applications beneficial, a few noted initial challenges or confusion. For example, Sena found iNaturalist somewhat challenging: "iNaturalist was a bit confusing at first, but I solved the application by asking my friends for help." Overall, PTs found mobile applications to be valuable tools for identifying and learning about organisms, praising their ease of use, speed, and interactive features.

Discussion

The inquiry report results indicate a broad spectrum of PTs' inquiry engagement, ranging from coherent inquiry processes to limited inquiry engagement. While many PTs' reports were structured with clear research questions and evidence-based explanations (Levels 1 and 2), some were not structured to represent the links between observations and questions or presented solely descriptive observations in the absence of an inquiry focus (Levels 3 and 4). These results support the importance of engaging PTs in inquiry-based science learning as learners of science (Stuchlikova et al., 2013; Weld & Funk, 2005). Similar findings in other research indicated that the PTs have challenges in setting researchable and specific questions (Cruz-Guzmán et al., 2017, 2020) and had difficulty in designing inquiry investigations (Plummer & Tanis - Ozcelik, 2015). This variation in the coherence of inquiry points to the need for further instructional support to help PTs integrate inquiry elements together meaningfully within investigations. Specifically, there is a need for explicit guidance in framing research questions, as they provide a foundation for effective inquiry-based learning.

In this study, PTs engaged in nature investigation after electricity investigations, where they posed research questions and conducted controlled experiments. However, findings indicate that it takes more experience to build research questions based on different contexts, relate data to questions, and provide clear explanations on various inquiry topics. This was consistent with the previous studies that indicated an explicit need for guidance during various phases of inquiry (García-Carmona, 2016, 2017). Scaffolding can play an integral role in assisting PTs in properly structuring coherent inquiry investigations with a deeper understanding of inquiry-based science learning.

The reflections portrayed the multifaceted nature of PTs' perception of nature investigation, including enhanced scientific and technological knowledge, a fostered connection to nature, and increased awareness of biodiversity. PTs reflected on their awareness of adaptations, habitats, and ecological changes. The findings suggest that nature investigation fosters deeper connections to the environment and sparks curiosity and responsibility for the environment, consistent with the place-based education framework (Semken - Freeman, 2008; Sobel, 2005). In addition, it aligns with the research in highlighting the influence of outdoor education in fostering environmental awareness and commitment to it (Chawla, 2015; Soga & Gaston, 2016; Trautmann, 2013; Wals et al., 2014). Reflections also point to their acknowledgment of knowledge gaps and a lack of prior attention to local biodiversity, emphasizing the value of localized, inquiry-based education beneficial for ecological and self-awareness in teacher preparation.

PTs described the experience as fun, motivating, and beneficial, suggesting that place-based learning can increase engagement and enjoyment in learning. The findings also showed that nature investigation contributed to PTs' holistic well-being, offering stress relief and motivation during the lockdown period. This is particularly important in the COVID-19 pandemic, where maintaining motivation and engagement in virtual or socially distanced environments has been a challenge (Avsar - Erumit et al., 2021). These reflections emphasize the broader benefits of nature-based investigations, not only for their educational value but also for their ability to support mental and emotional well-being. The connection between nature and well-being is well-documented (Gill, 2014; Louv, 2016), and this study highlights the importance of integrating such experiences into educational programs, particularly during times of heightened stress, such as the COVID-19 pandemic.

While most PTs had positive experiences, some expressed fear-related concerns about animals and discomfort related to environmental factors or the limitations imposed by the pandemic. Fear-related concerns, especially with invertebrates, were also reported in previous studies (Melis et al., 2021; Prado et al., 2020). During the introduction of the nature activity, PTs viewed a video about microhabitats, which elicited negative emotions in some participants, particularly regarding investigating insects. We discussed their role as adult models in future classrooms, emphasizing the importance of avoiding the transfer of biophobic attitudes to their students. Despite this guidance, a few PTs' reflections still showed fears related to insects. These concerns are important to address in future nature-based investigations, as they can act as barriers to full engagement. Providing clearer guidance, better preparation, and choosing accessible and comfortable environments could help mitigate these issues and ensure that all participants can participate without fear or discomfort.

PTs considered mobile applications effective for identifying and learning about organisms, highlighting their ease of use, speed, and accessibility. The varied experiences of PTs with these applications show the potential value of applications in supporting their observations and science learning. Most PTs found mobile apps helpful in quickly identifying organisms and gaining information, aligning with existing research on the benefits of mobile technologies in science education (Van Praag & Sanchez, 2014). These digital tools facilitated real-time identification and knowledge acquisition, reflecting the growing importance of digital literacy in science education (Sung et al., 2016). They particularly appreciated the practicality, rich data, and interactive features of the tools, which made learning quick and engaging. These positive perceptions align with findings by Echeverria et al. (2021), who reported that students found iNaturalist enjoyable and easy to use and expressed interest in future use, emphasizing its pedagogical benefits. The pedagogical advantages of mobile devices include increased motivation, enhanced content delivery (Sung, Chang, & Liu, 2016), greater authenticity in learning experiences, and improved student autonomy (Van Praag & Sanchez, 2014). Integrating mobile technologies into nature-based activities provides a powerful combination of traditional observation and modern technological support, enhancing content knowledge, engagement, and interest (Unger et al., 2020).

Despite these advantages, a few PTs encountered challenges in the apps, highlighting the importance of user-friendliness and additional support to maximize their effectiveness. For example, some PTs faced initial difficulties due to a lack of on-site instructor support, emphasizing the need for clear instructions and structured guidance, which were later provided during synchronous classes. Language barriers with iNaturalist, which defaults to English, also posed difficulties for some PTs. Peer feedback during class discussions helped resolve these issues, but the challenges emphasize the importance of scaffolding and modelling the use of mobile tools in educational settings. These findings suggest that mobile applications can be effective tools for scaffolding observation and classification skills and supporting inquiry-based environmental education by bridging digital and field-based learning experiences.

Limitations

While these findings should be considered in the context of certain limitations, they still provide valuable insights into PTs' engagement with inquiry-based place-based learning. The online nature of the course, necessitated by the COVID-19 pandemic, may have influenced PTs' engagement and the overall quality of observations. The absence of in-person guidance and supervision during the observations might have limited the depth of observations compared to a traditional field-based setting. Additionally, variations in PTs' access to resources, such as reliable internet and conducive natural environments, could have affected the observation experience. Differences between urban and rural environments likely influenced the depth and scope of nature observations, highlighting an area for future research to explore how different settings influence PTs' learning experiences and outcomes in nature-based investigations. The three-week duration of the nature investigation, while practical within the course schedule, may have constrained opportunities for PTs to further develop their inquiry skills and ecological awareness. Despite these challenges, the study emphasizes the potential of mobile-supported, place-based investigations in enhancing PTs' inquiry skills and biodiversity knowledge, even in remote learning contexts.

Conclusion

This study highlights the potential of combining place-based education, mobile technologies, and inquiry-based learning for PTs' development of scientific knowledge, inquiry skills, and ecological awareness. By engaging PTs in local nature investigations supported by digital tools, the study fostered both cognitive and effective outcomes, enhancing PTs' scientific knowledge, curiosity, and connection to their surroundings. The findings highlight the importance of scaffolding inquiry processes and addressing challenges such as fear or discomfort to ensure inclusive and meaningful engagement in nature-based learning.

Recommendations

Given the varying levels of PTs' inquiry coherence, there is a clear need for explicit instructional guidance in framing research questions, designing investigations, and making evidence-based connections between observations and explanations. Scaffolding strategies should be emphasized in teacher education to help PTs develop stronger inquiry practices. Additionally, mobile applications provide valuable support for nature-based learning, yet their effectiveness can be enhanced through structured integration and instructor facilitation.

Future research should explore the long-term impact of such inquiry-based experiences on PTs' teaching practices and their ability to facilitate similar learning experiences for their students. Investigating the influence of extended engagement in nature investigations and the role of different environmental settings (urban vs. rural) on PTs' learning can further inform best practices in science teacher education. The findings from this study contribute to the growing body of literature on nature-based learning and emphasize the importance of fostering inquiry, environmental awareness, and digital literacy in teacher preparation programs.

Scientific Ethics Declaration

* The author declares that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the author.

* IRB approval was received from Aydin Adnan Menderes University Educational Research Ethics Committee, with the decision dated August 6, 2021 (Session No: 18, Decision No: III).

Conflict of Interest

* The authors declare that they have no conflicts of interest

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