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ARTICLE

Nature-based Exposures of Learners to Elicit Discovery-Oriented Skills and Behaviors

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ABSTRACT

Nature-based learning is essential for holistic child development, as it integrates direct experiences with the natural environment into educational practices. It cultivates environmental awareness and stewardship, preparing students to be more conscious and responsible toward ecological sustainability. This paper explored the experiences of science high school teachers in implementing nature-based learning in science education and identify the changes in students' discovery-oriented skills. This qualitative exploration provides insights into the role of nature-based learning in shaping students' inquiry skills and their overall engagement in science education. High school science teachers (n = 30) from Central Visayas, Philippines were purposively sampled to be interviewed. The findings indicated that exposure to nature-based learning environments cultivated key discovery-oriented skills, including problem-solving, curiosity, and observation. Students were engaged in real-world environmental challenges, developing adaptive problem-solving abilities through experiences such as field research and ecosystem assessments. Curiosity can be developed as students encountered dynamic natural settings that encouraged inquiry and independent exploration, leading to engagement with scientific phenomena. Observation skills were also relevant, as students learned to track patterns, recognize trends, and make scientific predictions. Furthermore, nature-based educational activities contributed to behavioral shifts, encouraged a growth mindset, resilience, and increased inquisitiveness. Learners embraced uncertainty as a natural aspect of scientific exploration, demonstrating a willingness to adapt their approaches and seek deeper understanding through analytical questioning. There is a promise of integrating nature-based learning into educational policies and pedagogical development by promoting inquiry-based instruction, encouraging adaptive problem-solving skills, and strengthening growth mindset among students.

Keywords: Experiential Learning; Nature-Based Learning; Science Education; Science Skills

1. Introduction

Exploring the impact of natural environments on learning processes has become a critical area of focus in education. This research seeks to identify specific discovery-oriented skills that learners cultivate through exposure to nature-based educational settings, while also examining how such environments bring about significant behavioral transformations.

According to Dalimunthe et al.[1], a conducive and supportive learning environment is instrumental in enhancing student motivation and engagement. Similarly, Kuo and Jordan[2] underscore the importance of understanding how nature experiences shape learning and development. The study is rooted in the belief that interaction with ecological settings provides learners with unique opportunities for cognitive and behavioral growth, emphasizing the potential of nature as an effective tool for fostering holistic development.

A central framework guiding this investigation is ecopsychology, which explores the influence of natural surroundings on mental processes and behaviors. Immersing students in outdoor environments encourages active participation and strengthens their connection to nature, fostering curiosity and inquiry. Ecopsychology highlights the deep bond between humans and the natural world, illustrating how exposure to natural settings can positively affect mental health and behavior. Engaging learners in activities such as observing wildlife or analyzing ecosystems enhances their educational experiences and personal growth.

Early studies found that exposure to nature cultivates essential traits like adaptability, persistence, and a profound appreciation for the environment, which are crucial for discovery and exploration[3,4]. Similarly, integrating ecopsychological principles into education not only fosters a healthier relationship with nature but also contributes to improved emotional well-being and academic outcomes[5,6].

Cognitive development is another critical aspect of nature-based learning. Immersing learners in natural environments enhances cognitive skills by engaging them in observation, pattern recognition, and critical thinking. Such experiences enable students to connect abstract concepts with real-world applications, thereby strengthening problem-solving and data analysis skills. For instance, studies[7,8] discovered that children involved in nature-based activities exhibit improved concentration and memory, leading to better academic performance and overall development. This approach not only stimulates curiosity and inquiry but also enables students to synthesize knowledge across disciplines [9].

However, there is still limited understanding about the potential of nature-based activities in learning. For example, establishing well-defined and structured design principles could serve as a foundation for implementing nature-based learning effectively in real-world settings, facilitating greater consistency across various programs and strengthening the evaluation of its impact on specific outcomes [10]. Consequently, further research is needed to explore how different environmental factors, cultural contexts, and pedagogical approaches influence the effectiveness of nature-based learning. This paper aims to discuss the practical applications of integrating nature-based activities into educational frameworks in the context of science education, emphasizing its role in developing cognitive, social, and emotional development among students.

2. Literature Review

Nature-based learning has emerged as an effective method for nurturing discovery-oriented skills and behaviors in learners. Early childhood education, in particular, has increasingly embraced nature as a diverse source of environmental learning opportunities [11]. Through direct interaction with natural elements, such environments stimulate children's curiosity, problem-solving abilities, and creativity [12]. This educational approach highlights the value of immersive experiences, enabling students to engage with the world around them in ways that develop both cognitive and behavioral skills.

Research emphasizes that these exposures provide hands-on learning opportunities, interdisciplinary connections, and problem-solving experiences that are often absent in conventional classroom environments. There is a need for applying knowledge in practical contexts to cultivate complex skills [13]. Similarly, expertise development theories [14] suggest that learners achieve advanced competence in solving intricate problems when they build on prior knowledge and engage in extensive practice. Nature-based education not only enhances academic learning but also equips students with the skills necessary for addressing real-world challenges through a comprehensive and integrated approach [15].

A significant advantage of this approach lies in its capacity to nurture *discovery-oriented skills*. These include critical thinking, inquiry-driven learning, and keen observation, all of which are fundamental to scientific exploration [16]. Exposure to natural settings has been associated with numerous benefits, such as enhanced attention, reduced stress, improved mood, and a lower risk of psychiatric disorders [17]. Learners in these environments often exhibit heightened curiosity and deeper engagement with their studies. For example, outdoor activities like observing ecosystems or conducting experiments enable students to bridge theoretical concepts with practical applications. Ayotte-Beaudet et al. [18] noted that some learners developed a sense of connection with nature, even without directly addressing environmental concerns during these activities. This hands-on approach transforms students into active participants in their education, moving away from passive absorption of information.

Traits such as adaptability, perseverance, and teamwork naturally emerge as students navigate unpredictable and ever-changing conditions [19]. Teachers have observed that learners in these settings demonstrate greater independence and problem-solving capabilities. Mukuka et al. [20] found that more than 53% of teachers acknowledged making substantial efforts to foster these behaviors in their students. For instance, challenges like fluctuating weather or unexpected variations in field data compel students to adapt and devise innovative solutions. This capacity to overcome obstacles not only enhances their immediate learning outcomes but also prepares them for future academic and professional demands.

Kavak [21] investigates the link between creativity and scientific process skills in preschoolers engaged in nature-based education using a relational screening model. The sample includes 34 children aged 4 to 5 from a kindergarten in Konya, Turkey, selected through purposive sampling. Data were gathered using the Scientific Process Skills Test (SPS) and the Early Childhood Creativity Scale (ECCS), both validated for Turkish culture. The SPS assesses three dimensions of scientific skills, while the ECCS measures creativity on a 7-point Likert scale. Findings suggest that nature-based education enhances both creative and scientific thinking, supporting its role in early childhood skill development.

DeGoede [22] argued that while nature-based learning is recognized for its positive impact on elementary students' development, its integration into curricula remains inconsistent. Research highlights the overall benefits of nature on learning and child development, including cognitive, social, emotional, and physical growth. Studies also emphasize its role in developing a deeper connection with nature, enhancing psychological well-being, and mitigating cognitive stressors. Despite these findings, gaps remain in understanding how to systematically implement nature-based, underscoring the need for further research on its long-term effects and optimal integration strategies.

Nature-based education transforms how students learn, equipping them with skills and behaviors that extend far beyond academic contexts. The global interest in both nature-based play and learning continues to grow[23–25]. While definitions may vary, nature-based involves unstructured interaction with natural elements, whereas nature-based learning incorporates these elements to enhance instruction across various subjects, both indoors and outdoors[26,27].

Engaging deeply with natural settings fosters not only academic achievement but also emotional and social growth. As students navigate the complexities of the natural world, they cultivate resilience, curiosity, and critical thinking—qualities essential for lifelong learning and exploration. The expanding body of research in this field underscores the importance of integrating nature-based methods into educational systems to prepare students for the challenges of an interconnected and rapidly evolving world.

3. Methods

3.1. Research Design

This paper explored the experiences of science and environmental education teachers in nature-based educational activities. They were asked about how experiential learning opportunities empower students for discovery-oriented skills and develop behavioral changes towards environmental protection. Exploratory research analyzes significant concerns and uncovers underlying mechanisms through a structured investigative process[28,29]. In social sciences, this utilizes systematic and intentional methodologies to detect key trends, allowing for the examination and interpretation of social and psychological phenomena[30,31]. These investigations often provided a preliminary basis for generating hypotheses that could later undergo empirical validation[32]. Despite criticisms regarding its supposed methodological limitations, contemporary scholars have highlighted its importance in establishing understanding about a phenomenon and ensuring the systematic acquisition of critical data[33]. With qualitative exploration, this paper answered one essential question: how could experiential learning through nature-based exposure develop discovery-oriented skills among learners? Findings from this research contribute to the broader discourse on learner-centered pedagogies, emphasizing the significance of experiential methods in promoting self-directed inquiry and lifelong learning.

3.2. Participants

Exploratory research has traditionally employed a limited sample size to facilitate an in-depth examination of critical variables and their interrelationships[34]. These investigations frequently concentrated on a targeted group of participants to achieve a comprehensive understanding of specific phenomena[35,36]. The determination of sample size remained flexible, oftentimes the participants' ability to provide substantive contributions to the research objectives[37–39]. A commonly employed non-probability sampling method, purposive sampling, involves the intentional selection of individuals based on their characteristics or relevance to the study[40,41]. This technique enabled researchers in this study to identify participants whose expertise or lived experiences provided critical insights into the research inquiry[42]. In the present study, an online purposive sampling approach was applied[43], wherein open-ended questions were distributed via Google Forms to gather preliminary data from respondents. The gathered responses were then evaluated and screened to ensure the selection of individuals who met the criteria. There were five characteristics established: (1) a high school teacher (> 5 years of experience), (2) teaches science and/or environment subjects, (3) a graduate of science-related bachelor's and graduate degree, (4) conduct in-field activities (site observations, hands-on experiments, participant interviews, and real-time data collection), and (5) willingness to participate in one-on-one interviews. There were 134 teachers who responded to the online survey, but only 30 from Central Visayas, Philippines were selected to be interviewed. **Table 1** presents the information of sampled 30 high school teachers.

Table 1. Basic information of sampled participants.

No.	Name	Sex	Age	Nature-Based Activities for Students
1	Anna	Female	32	Tree planting
2	Mark	Male	40	Outdoor scavenger hunt
3	Lisa	Female	35	Garden maintenance
4	John	Male	38	Nature journaling
5	Emma	Female	41	Bird watching
6	Paul	Male	36	River clean-up
7	Grace	Female	39	Composting workshop
8	Leo	Male	34	Hiking and ecosystem study
9	Sarah	Female	42	Nature sketching
10	Tom	Male	37	Wildlife observation
11	Nina	Female	33	Seed planting
12	Eric	Male	45	Environmental storytelling
13	Amy	Female	31	Leaf classification
14	Ryan	Male	43	Park clean-up
15	Chloe	Female	38	Outdoor science experiments
16	Jake	Male	44	Tree identification
17	Mia	Female	35	Nature photography
18	Adam	Male	30	Sustainable gardening
19	Zoe	Female	37	Rock and soil exploration
20	Mike	Male	42	Insect habitat study
21	Bella	Female	34	Outdoor art activities
22	Sam	Male	39	Water conservation projects
23	Olivia	Female	41	Tree bark rubbing activity
24	Ben	Male	33	Nature storytelling sessions
25	Ruby	Female	36	Butterfly garden observation
26	Chris	Male	46	Coastal clean-up
27	Ella	Female	32	Rainwater collection activities
28	Kevin	Male	40	Mapping local biodiversity
29	Sophia	Female	44	Creating bird feeders
30	David	Male	31	Plant growth observation

3.3. Instrumentation

In qualitative research, the dependability and trustworthiness of findings were significantly shaped by the data collection strategies employed [44,45]. To ensure coherence and methodological rigor throughout the interview process, a semi-structured interview guide was developed [46]. This guide presents formulated questions, thematic focus areas, and specific discussion points to maintain a systematic approach that framed critical aspects of the research [47]. The development process followed the framework outlined by Kallio, Pietilä, Johnson, and Kangasniemi [48], which involved establishing prerequisites, synthesizing existing literature, drafting an initial guide, conducting a pilot test, and refining the final instrument. Expert evaluation was conducted to enhance the validity and alignment with the research objectives [47]. It involved specialists from education, social sciences, psychology, and linguistics, who evaluated the clarity, relevance, comprehensiveness, and alignment with the study objectives. In addition, conducting a pilot test was an essential phase in ensuring the clarity, relevance, and capacity of the questions to generate rich and meaningful responses [49]. In pilot testing, participants (n = 7) were asked to respond to the interview questions. Their feedback was analyzed to assess clarity, relevance, response patterns, and potential ambiguities in the instrument. **Table 2** below presents the final guide questions used in this study.

3.4. Data Gathering Procedure

The researchers identified participants through criterion sampling and contacted science and environmental educators who met the inclusion criteria. Informed consent was obtained from all participants before conducting interviews. Respondents were provided with a letter of consent and clear instructions about the process. They were encouraged to ask questions to clarify any uncertainties before proceeding [50]. The interviews were audio-recorded to ensure the reliability and accuracy of the data collected. Participants were encouraged to share detailed narratives and specific examples of the skills and behaviors they observed in learners exposed to nature-based activities. Throughout the process, ethical considerations, including confidentiality and data security, were strictly upheld.

Table 2. Final guide questions used during the interviews.

Objectives	Interview Questions	Thematic Identifier
Determine discovery-oriented skills honed through nature-based settings exposures.	1. Can exposures to more natural environmental settings hone discovery-based skills among learners? Elaborate how. 2. What certain discover-oriented skills can be developed among learners if they are expose to nature-based educational settings? Explain and elaborate each. 3. How important is it to developed discovery-oriented skills among students using the natural environmental settings? Explain further.	– Enhancing inquiry and problem-solving through nature exposure. – Critical thinking, creativity, adaptability, and observation. – Long-term benefits of nature-driven experiential learning.
Determine behavior shifts of learners when expose to environment educational activities.	1. What important behaviors can change among learners that is important to discovering science ideas when exposed to nature-based learnings? 2. As a teacher, what have you observed among your learners when they are exposed to nature-based learnings in relation to their science skills? 3. What is it with nature-based settings that makes learning about science becomes positively productive among students?	– Examining how nature-based learning develop curiosity, patience, and analytical thinking. – Teachers' perspectives on students' improved observation, inquiry, and problem-solving abilities. – How immersive environments enhance engagement and conceptual understanding in science.

3.5. Data Analysis

Thematic analysis, a qualitative research approach, was conducted to identify, categorize, and interpret patterns within the data [51,52]. Its inherent flexibility was appropriate for this exploratory study, as it allowed themes to emerge organically from the data without being constrained by pre-established concepts [53,54]. The analytical process started with the systematic generation of descriptive codes, which were subsequently synthesized into higher-order interpretive themes, which elucidates underlying relationships within the narratives [55]. Particularly, the study adopted reflexive thematic analysis, an approach that encourage the active engagement of researchers with the data while integrating reflexivity mechanisms to mitigate potential biases [56]. Reflexive thematic analysis recognized the researcher's subjectivity as an intrinsic component of the analytical process, using it to enhance the depth, coherence, and richness of interpretation rather than perceiving it as a methodological limitation [57,58]. As illustrated in **Figure 1**, this approach adhered to the iterative six-phase framework from Braun and Clarke [51]: (1) immersion in the data, (2) systematic coding, (3) theme identification, (4) theme refinement, (5) theme definition and categorization, and (6) final synthesis and reporting. To uphold methodological rigor and minimize potential biases, the study employed an inductive analytical approach, ensuring that the themes were data driven. Inductive thematic analysis allowed development of codes and themes directly from the data, allowing the researcher to transition from specific codes to broader conceptual generalizations [59].

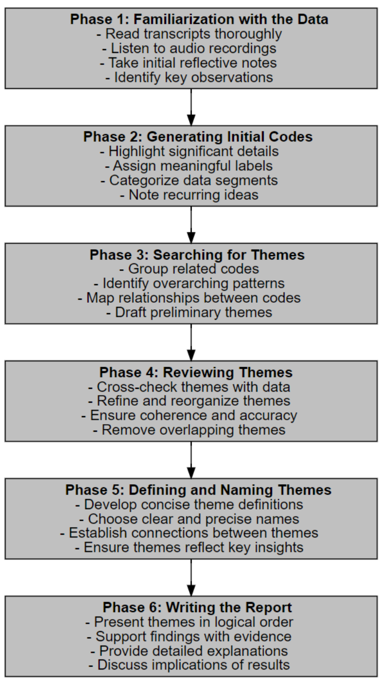

Figure 1. Workflow of data analysis process.

4. Results

Objective 1: Determine discovery-oriented skills honed through nature-based settings exposures.

The findings revealed that exposure to nature-based learning environments encouraged the development of key discovery-oriented skills, including problem-solving, curiosity, and observation skills. Nature-based learning provided an immersive and experiential platform for students to develop essential scientific skills, reinforcing their ability to analyze, adapt, and explore complex real-world phenomena.

Problem-solving skills were enhanced as students deal with real-world challenges requiring adaptability and critical thinking. Field research experiences, such as investigating ecosystem health or air quality, reinforced their ability to adjust methods and design approaches when faced with challenges.

Curiosity emerged as a fundamental skill cultivated through nature-based learning. The dynamic and changing natural environment encouraged students to question, explore, and formulate their own hypotheses. Observing plant growth, animal behavior, or ecological interactions prompted independent inquiry, developing a mindset that extended beyond structured academic learning and into lifelong scientific exploration.

Lastly, observation skills were significantly strengthened as students engaged in detailed monitoring of environmental patterns. The need to track variables such as climate changes, species behavior, and ecosystem shifts honed their ability to recognize patterns, make predictions, and formulate scientific explanations. Fieldwork allowed students to develop a keen awareness of subtle changes, a skill critical for scientific inquiry and research.

Theme 1: Problem-solving Skills

Science teachers observed that exposure to nature-based learning positively developed students' problem-solving skills by engaging them in real-world environmental challenges. Participants encountered complex and unpredictable scenarios that required them to develop adaptive strategies and engage in critical thinking.

"One of the most powerful aspects of nature-based learning is the need to solve real-world environmental problems."

"In natural settings, students encounter real-world challenges that require creative problem-solving, which is a crucial component of discovery-based learning."

Nature-based learning enhanced students' ability to think critically and adapt when faced with real-world challenges. Engaging in tasks that required analyzing environmental conditions, interpreting data, and making informed decisions developed their scientific reasoning and problem-solving skills.

"These tasks encourage them to adapt to changing conditions, improvise with available resources, and think outside the box skills that are fundamental in scientific discovery."

For example, when assessing an ecosystem's health, students collected data on water quality, plant life, and wildlife populations. They then examined patterns and identified factors influencing environmental changes, such as pollution, climate variations, or habitat destruction. This process required them to think systematically and propose evidence-based solutions.

"For example, when tasked with studying the health of an ecosystem, students must gather data, analyze it, and think critically about factors affecting the environment."

"...they need to think critically about what factors are contributing to the problem."

Similarly, field research often involved unexpected difficulties, such as equipment failure, bad weather, or external disturbances (e.g., construction activity affecting air quality measurements). These challenges forced students to modify their approach, such as switching to alternative tools, adjusting their data collection schedule, or redefining their research focus.

"When students conduct field research on air quality in a rural area, they might encounter problems like equipment malfunction or unexpected interference from nearby construction projects. These disruptions require them to think creatively and adapt their methods."

"Maybe they need to use a different set of tools, adjust their sampling schedule, or reframe their research question."

Students developed critical problem-solving abilities by engaging in unstructured and unpredictable nature-based learning experiences. Scientific research is rarely straightforward, and unexpected obstacles—such as equipment malfunctions, environmental changes, or external disruptions—often arise.

"These types of problem-solving skills are critical for students, as they learn that scientific research requires flexibility and quick thinking when things don't go according to plan."

Theme 2: Curiosity

Science teachers reported that nature-based learning encouraged curiosity by exposing students to dynamic, real-world phenomena that encouraged them to ask questions and seek answers. Unlike traditional classroom learning, where knowledge is often presented in a structured format, natural environments presented unpredictable and complex scenarios that prompted students to think independently and explore solutions on their own.

"Nature provides an ongoing source of questions and exploration."

"Exposure to natural environments encourages students to think independently and pursue their own discoveries."

"When they see science as something they can explore, rather than as a set of memorized facts they are more likely to continue seeking knowledge throughout their lives."

Similarly, watching animal behavior—such as birds migrating or insects pollinating flowers—could inspire inquiries about ecosystem interactions and environmental changes. When students encountered phenomena they did not immediately understand, they naturally sought answers by researching, making observations, and testing ideas.

"For instance, observing the growth patterns of plants or the behaviors of animals encourages curiosity and inquiry."

"When students encounter something, they don't understand...they may naturally explore ideas."

Students who learned to view science as a process of exploration rather than rote memorization became more likely to pursue careers in research, innovation, and problem-solving fields. Their curiosity, nurtured in nature-based learning, extended beyond the classroom and influenced their approach to challenges in academia, professional careers, and daily life.

"Their natural curiosity leads them to develop their own research questions and hypotheses, which is a crucial skill for any aspiring scientist."

"Students who develop this habit early in their academic careers are more likely to seek out new knowledge, pursue scientific interests, and contribute to future innovations."

"...students may develop a mindset of curiosity that drives lifelong learning."

Theme 3: Observation Skill

Science teachers noted that nature-based learning sharpens students' observation skills by requiring them to pay attention to details in an ever-changing environment. Through continuous exposure to natural settings, students develop the ability to track patterns, recognize trends, and make predictions—key components of scientific inquiry.

"One of the primary skills that students develop in nature-based settings is keen observation."

"Nature provides an ever-changing environment where students must pay close attention to detail to track variables like plant growth, animal behavior, or weather patterns."

"Observing nature over time helps students develop pattern recognition, a key skill in scientific inquiry."

For example, a student observing a plant's growth over several weeks may notice that more sunlight leads to faster growth, helping them understand photosynthesis and environmental influences. This process of careful observation helps students identify cause-and-effect relationships, develop hypotheses, and make scientific predictions. Unlike passive learning in a classroom, fieldwork trains them to notice subtle changes—such as variations in leaf color indicating soil nutrient levels—that they might otherwise overlook in textbooks.

"For instance, when students study weather patterns and notice that certain conditions, like temperature or humidity, are associated with changes in local ecosystems, they can begin to predict how those changes might affect other factors, such as plant or animal behavior."

"Pattern recognition is important for scientific inquiry because it helps students generate hypotheses and make predictions."

"...engaging in fieldwork, students become adept at noticing subtle differences and changes that might otherwise be overlooked in a classroom setting."

Objective 2: Determine behavior shifts of learners when exposed to nature-based educational activities.

Science teachers observed that exposure to nature-based learning environments placed students in unpredictable situations, requiring them to interpret incomplete data and navigate uncertainty. As students engaged in real-world observations and investigations, they gradually developed a growth mindset, sense of curiosity, and engagement.

Instead of viewing challenges as obstacles, students perceived them as opportunities for learning and improvement. They adjusted their strategies in response to unexpected outcomes, refining their ability to approach scientific problems with creativity and adaptability.

Teachers reported that students exposed to nature-based activities exhibited greater curiosity compared to those in traditional classroom settings. Learners began asking more in-depth questions about natural phenomena, such as plant growth, animal behavior, and environmental changes.

In fieldwork settings, students had to resolve conflicts, assign roles, and work toward common research objectives. Each participant brought new perspectives to the investigation, enriching the overall learning experience.

Theme 1: Growth Mindset

Science teachers noted that nature-based learning engaged students in dynamic and unpredictable settings, where they had to analyze incomplete data and adapt to evolving conditions. Initially, many learners found these situations intimidating, yet over time, they became more accustomed to uncertainty and recognized it as an inherent aspect of scientific exploration.

"Nature-based learning often places students in unfamiliar or unpredictable environments where they are required to make sense of new and incomplete data. This can initially be intimidating, but over time, they become more comfortable with the idea that uncertainty is part of scientific exploration."

As students engaged with nature, they gradually developed a growth mindset. Rather than fearing failure or uncertainty, they perceived these challenges as opportunities for learning and improvement. They adapted their approaches in response to unexpected outcomes, demonstrating a greater willingness to explore and refine their scientific understanding.

"Exposure to nature helps students develop a growth mindset, where they are not afraid of failure or uncertainty but rather see it as a learning opportunity."

"Students learn to embrace challenges and adjust their approach in response to unexpected outcomes."

In fact, some students gained confidence in their ability to address scientific problems, approaching them with creativity and an open mind. This shift reflected their increasing resilience and adaptability in the face of challenging scientific inquiries.

"Some students gain confidence in their ability to face scientific problems with a creative and open-minded approach."

Theme 2: Seeking Answers

Science teachers observed a significant behavioral shift in students when exposed to nature-based activities, as their curiosity became more pronounced compared to traditional classroom settings. Students demonstrated increased inquisitiveness, posing more questions about plant growth, animal behavior, and the effects of weather on ecosystems.

"Exposure to nature-based activities sparks curiosity in students in ways that a traditional classroom setting doesn't always do."

"They ask more questions about how plants grow, why animals behave in a certain way, or how the weather impacts ecosystems."

Engagement in these activities led students to formulate more analytical questions, moving beyond superficial inquiry. This transition from passive knowledge absorption to active exploration signified a fundamental shift in their approach to learning.

"In the field, students often discover things they didn't expect, which ignites a deeper desire to learn and understand."

"...when they're engaging in these activities, they begin asking deeper, complex questions."

Science teachers observed that students' questions evolved from simple, surface-level inquiries to deeper, more meaningful explorations driven by genuine curiosity. Instead of merely accepting facts, students engaged in independent exploration, forming their own questions, investigating scientific phenomena, and developing a more inquiry-driven approach to learning.

"Questions are not just surface level they show genuine curiosity. This is a crucial shift because it moves them from passive reception of information to active exploration and inquiry."

This transition from passive knowledge absorption to active exploration highlighted a fundamental shift in their approach to learning. Teachers noted that this behavioral change naturalized critical scientific skills, particularly in developing hypotheses and conducting empirical investigations through direct observation and experimentation.

"This shift from a passive to an active mode of inquiry helps students develop stronger science skills, especially in forming hypotheses and testing their ideas through direct observation and experimentation."

Theme 3: Engagement

Science teachers observed a notable behavioral shift in students as they engaged in nature-based learning, particularly in their ability to collaborate effectively. Initially, students exhibited challenges in resolving conflicts and coordinating tasks; however, over time, they demonstrated improved communication skills and a greater willingness to negotiate roles, reconcile differing viewpoints, and work collectively toward shared objectives.

"This is where collaboration in nature-based learning becomes especially valuable it provides a setting where students must practice conflict resolution."

"Students will need to discuss their observations, design experiments, and share findings."

In fieldwork, students transitioned from working in isolation to collaborating effectively in data collection, result interpretation, and problem-solving. Each student contributed unique insights, applying their individual strengths to the group's collective understanding.

"In the field, students often work together to collect data, analyze findings, and solve problems."

"They need to negotiate roles, resolve differences in opinion, and work together towards a common goal."

Through this process of collaborative inquiry, students came to understand that science was not a rigid set of facts but rather an evolving discourse that required continuous questioning, testing, and refinement of ideas.

"Each student might approach the task from a different angle, contributing their own expertise and ideas."

"This process of collaborative inquiry helps students understand that science is a dynamic, ongoing conversation."

As students engaged in these collaborative tasks, they developed essential interpersonal skills, including effective communication, teamwork, and adaptability. Science teachers noted that this shift in behavior was crucial in preparing students for future professional settings, where scientific and academic success often depended on the ability to work cohesively within a team.

"Learning how to deal with these dynamics and find solutions that benefit interpersonal skills...it will help students prepare for professional environments where teamwork and collaboration are often key to success."

5. Discussion

Engaging directly with natural environments allows students to bridge theoretical knowledge with practical, real-world applications. Experiential learning, a method that promotes understanding through direct experience, reflection, and active participation, was integral in this process. Activities like observing biological processes and analyzing environmental changes help learners sharpen their observation and data collection skills. These immersive experiences in nature foster heightened awareness and mental engagement, encouraging curiosity and inquiry-driven learning [60].

Nature-based learning environments compel students to confront unpredictability, refine their strategies, and resolve complex environmental challenges [61]. This process supports the development of cognitive flexibility, enabling learners to navigate obstacles through innovative and creative solutions.

Early studies indicate that learning emerges from dynamic interactions between individuals and their surroundings [62]. Persistent and lasting patterns of human learning develop through repeated engagements between a person and their environment [63]. The manner in which individuals interpret and respond to new experiences shapes the range of options and decisions they perceive. These choices and decisions, in turn, influence the events they encounter, which subsequently shape future decision-making processes [64]. For example, science teachers observed that students who were repeatedly exposed to outdoor educational activities demonstrated a significant shift in their learning behavior. Initially, many students exhibited hesitation when faced with unfamiliar, unpredictable environments. However, through continuous engagement, they adapted by developing problem-solving skills, embracing uncertainty, and developing a growth mindset. This transformation was evident in how they approached scientific inquiries—students who once passively received information in a classroom setting began actively questioning natural phenomena, forming hypotheses, and testing their ideas through direct observation. Likewise, individuals continuously shape their own development through the experiences they actively engage in and the decisions they make [64].

The findings of the study can be extended towards the concept of experiential learning processes. Experiential learning is depicted as a continuous and iterative learning cycle, in which individuals engage in a dynamic sequence of experiencing, reflecting, analyzing, and applying knowledge [64]. For instance, when students engaged in fieldwork, they initially encountered unfamiliar ecological phenomena (experiencing). They then reflected on their observations, questioning why certain plant species thrived in specific environments while others did not (reflecting). This curiosity led them to analyze the underlying biological and environmental factors influencing plant growth (analyzing). Finally, they applied their newfound understanding by designing small-scale experiments to test their hypotheses, such as investigating soil composition or water availability in different locations (applying). Through this recursive progression, learners actively adapt their understanding based on the specific learning context and the nature of the subject matter [65].

Fieldwork and extended projects in nature provide students with opportunities to develop perseverance by addressing and overcoming challenges. These experiences develop a mindset of persistence, which is vital for scientific inquiry and lifelong learning [66,67]. Exposure to unpredictable natural settings encourages learners to embrace uncertainty and take calculated risks in their scientific endeavors.

Further, the results illustrate that collaborative engagement in nature-based activities encourages students to work together and share perspectives to solve problems [68]. Ecopsychology highlights the role of collective interactions with natural settings in enhancing interpersonal skills, while cognitive psychology underscores the value of collaborative learning in promoting critical thinking and creativity. Creative thinking involves the ability to devise innovative solutions and address challenges through unique perspectives, involving originality as well as the critical refinement of ideas [69].

Future research could explore the long-term impact of nature-based experiential learning on students' academic performance and cognitive development. Longitudinal studies tracking students who engage in consistent outdoor learning experiences could provide insights into whether these methods lead to sustained improvements in scientific reasoning, problem-solving abilities, and overall academic achievement. Another promising avenue for research is the role of technology in enhancing nature-based learning experiences. Integrating digital tools such as augmented reality, mapping, or mobile data collection apps could provide students with interactive ways to analyze their surroundings while maintaining the hands-on nature of experiential learning.

6. Conclusions

The primary contribution of this study was its understanding of how nature-based learning environments could develop discovery-oriented skills such as problem-solving, curiosity, and observation. Exposure to real-world environmental challenges enhanced students' problem-solving abilities by requiring them to analyze, adapt, and develop evidence-based solutions. Through hands-on field research, students navigated unpredictable scenarios—such as assessing ecosystem health or overcoming research obstacles—encouraging flexibility and critical thinking. Curiosity was also significantly nurtured, as students engaged in self-driven inquiries prompted by dynamic natural phenomena. The unpredictability of nature encouraged students to ask questions, formulate hypotheses, and explore scientific concepts beyond structured academic settings.

Beyond skill development, the study also revealed notable behavioral shifts among students exposed to nature-based educational activities, particularly in their growth mindset, curiosity, and engagement. Students became more comfortable with uncertainty, perceiving challenges as opportunities for learning rather than obstacles. They developed resilience and adaptability, traits essential for scientific inquiry. Furthermore, their curiosity deepened, prompting them to ask more analytical questions about natural processes and to actively seek answers through independent exploration. Collaborative fieldwork experiences also improved teamwork and problem-solving, as students worked together to address research challenges.

There were limitations that needed to be acknowledged and addressed. One limitation of this study is the sample size, which, while sufficient for analysis, may not fully capture the diversity of perspectives needed for broader generalizability. The findings are context-specific and may not be easily applied to different settings or populations. Furthermore, limitations in methodology, including the selection of instruments and potential response biases, could impact the reliability and validity of the results. Future researchers may explore larger and more diverse samples to enhance generalizability, employ longitudinal studies to examine changes over time, and integrate alternative methodologies to strengthen data triangulation. Lastly, further studies could investigate related variables, such as the use of technology in education, the role of teachers' support, or comparative analyses across different educational institutions and disciplines.

Author Contributions

Conceptualization, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; methodology, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; software, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; validation, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; formal analysis, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; investigation, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; resources, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; data curation, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; writing—original draft preparation, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; writing—review and editing, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; visualization, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; supervision, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; project administration, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C.; funding acquisition, A.L.C., M.E.V.S., J.L.A., J.B.C.C., L.C.D.C, J.D.C., M.O.O., C.C.Z., C.L.R.Q., M.A.G.F., G.G.L.R, V.A.B, V.R.A. and E.D.C. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Ethical review and approval were waived for this study because it involved minimal risk to participants, did not collect sensitive personal information, and did not involve any intervention or manipulation.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data supporting the findings of this study are not publicly available due to a confidentiality agreement with the participants/organization involved.

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Conflicts of Interest

The authors declare no conflict of interest.

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