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Human–Nature Relationships and Science Process Skills in an Early Childhood Forest School Pilot Project

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Abstract

Growing concerns regarding children's disconnection from nature have increased interest in nature-based pedagogies within Early Childhood Education (ECE). This study examined how participation in a Forest School pilot project influenced children's learning environments, play, human–nature relationships, and science process skills in three ECE settings in Northern Spain. This longitudinal study combined quantitative and qualitative data collection methods to follow 106 children aged 2–5 years throughout a complete academic year of regular Forest School sessions integrated within mainstream schooling. Data collection combined systematic observation scales, semi-structured interviews, environmental attitude measures, and family questionnaires to examine learning environments, children's play, social interactions, environmental attitudes and science process skills. The findings indicate that forest environments provided richer opportunities for exploratory play, science process skills, and interaction with unstructured materials than conventional playgrounds. Group symbolic play occurred more frequently in forest settings, while lower levels of conflict were observed. Children progressively developed more ecocentric environmental attitudes, empathy toward living beings, and relational forms of environmental care through repeated interaction with nearby ecosystems. Teachers reported that children demonstrated increasing science process skills—including observation, exploration, representation, and communication—through direct interaction with natural phenomena. The study suggests that regular nature-based learning may support the development of science process skills, environmental care, and holistic child development within mainstream ECE contexts.

Keywords: forest school; nature-based learning; early childhood education; sustainability education; science process skills; environmental attitudes; STEM education; symbolic play; outdoor education; environmental care

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1. Introduction

Children's opportunities for direct contact with nature have declined considerably in recent decades due to increasing urbanization, reduced access to green spaces, heightened parental concerns regarding outdoor play and growing screen consumption (Kellert, 2012). As a result, many children experience progressive disconnection from nearby ecosystems, limiting both their environmental knowledge and their opportunities for experiential learning. Previous research showed that students living in urban contexts were often more familiar with exotic species from distant ecosystems than with local flora and fauna (Barrutia et al., 2022). This growing disconnect has increased interest in educational

approaches that provide children with regular opportunities to interact with nearby natural environments and develop meaningful human–nature relationships from an early age (Johnstone et al., 2022).

In response to these challenges, increasing attention has been paid to outdoor and nature-based pedagogies within ECE. A growing body of research has shown that regular interaction with natural environments may positively influence children's physical activity, emotional well-being, creativity, autonomy and social relationships (Dabaja, 2021; Johnstone et al., 2022). Natural environments have additionally been associated with restorative effects that reduce stress and support children's cognitive and socio-emotional development (Hartig et al., 2014; Kaplan, 1995). At the same time, scholars have argued that nearby natural environments may play an important role in fostering environmental awareness and pro-environmental attitudes during childhood (Collado et al., 2020; Johnstone et al., 2022).

Among nature-based educational approaches, Forest School has gained particular international relevance as a distinct pedagogical approach originating in Scandinavia and characterized by regular and repeated sessions in natural environments, child-led play, experiential learning, and sustained engagement with wooded spaces (Knight, 2009; Garden & Downes, 2023; Knight et al., 2024). Rather than considering nature merely as a setting for instruction, forest school pedagogies position the natural environment itself as a central educational resource (Cooper, 2015). Previous studies have suggested that such environments may promote symbolic play, collaboration, creativity, and engagement with ecological phenomena through direct experience and open-ended interaction with natural materials (Chancellor, 2007; Moore et al., 2009; Knight et al., 2024). Some authors use the concept of 'play biotopes' (Mårtensson et al., 2025) as a landscape, with its flora and fauna, that foster children's interaction with nature as part of their play settings.

Beyond their documented contributions to children's wellbeing and environmental awareness, Forest School has increasingly been recognised as an educational context that supports early science learning through direct engagement with natural phenomena, materials, and ecological processes. Its interdisciplinary theoretical foundations—including experiential learning, play pedagogy, biophilic interaction, and place attachment—provide opportunities for children to observe, compare, manipulate, and communicate about natural phenomena in authentic settings, thereby creating favourable conditions for the development of science process skills (Knight et al., 2024). Building on this potential, recent perspectives in early childhood STEM education additionally emphasize that STEM learning should not be understood as isolated disciplinary instruction, but rather as an interdisciplinary process involving opportunities for scientific inquiry, material investigation, representation, communication, and collaborative problem-solving situated within meaningful real-world contexts (MacDonald et al., 2022; Ng et al., 2022). From this perspective, young children develop STEM understanding through active exploration of materials, understanding of ecological phenomena, and everyday experiences that integrate scientific reasoning, creativity, experimentation, and embodied learning. Similarly, Trina et al. (2025) argue that nature-based outdoor environments contribute to preschoolers' STEAM learning by offering children affordances to nurture problem-solving or engineering skills. Contemporary perspectives on ECE emphasize that young children develop scientific understanding most effectively through active exploration and opportunities for scientific inquiry in meaningful contexts (Martin et al., 2005). In this regard, natural environments may provide opportunities for developing science process skills such as observation, classification, comparison, experimentation, and communication through direct interaction with ecological and physical phenomena. Some researchers have argued that repeated experiences in nature may additionally support the development of ecocentric attitudes

and environmental care through emotional connection and embodied experience rather than through abstract environmental instruction alone (Collado et al., 2020).

Despite the growing body of research on Forest School, important gaps remain. Much of the existing evidence derives from alternative educational settings, short-term interventions, or studies focusing on a single developmental outcome, while comparatively less attention has been paid to the long-term implementation of Forest School within mainstream public Early Childhood Education (Leather, 2018; Garden & Downes, 2023). Furthermore, ongoing debates remain regarding the extent to which reported outcomes can be attributed to children's contact with nature itself or to broader pedagogical characteristics, such as child-led learning, autonomy, experiential approaches, and opportunities for play (Leather, 2018; Waite & Goodenough, 2018; Knight et al., 2024). Recent reviews have also highlighted the need for more theoretically grounded, longitudinal, and context-sensitive research capable of examining how Forest School interacts with curricular objectives and public educational systems over time (Altuna, 2023; Egan et al., 2022; Garden & Downes, 2023; Knight et al., 2024). Addressing multiple educational outcomes simultaneously—including learning environments, play, human–nature relationships, science process skills, and family perceptions—may provide a more comprehensive understanding of the educational potential of regular nature-based learning.

To address these gaps, a Forest School initiative was developed in the Basque Country (Northern Spain), with the aim of integrating regular nature-based learning experiences into ECE settings through a mixed model combining classroom-based education with systematic sessions in nearby forest environments. Unlike full-time Forest School, this model sought to incorporate repeated contact with nature within mainstream schooling while maintaining connections with curricular objectives and public educational structures.

The aim of this study was to examine how participation in a Forest School pilot project implemented in three ECE settings influenced children's learning environments, play, human–nature relationships, science process skills, and families' perceptions of the educational experience. Specifically, the study addresses the following research questions:

RQ1. How do Forest School environments differ from conventional playgrounds as learning environments?

RQ2. How does participation in Forest School sessions influence children's play behaviours and social interactions?

RQ3. How do children's environmental attitudes and expressions of environmental care evolve throughout participation in the Forest School project?

RQ4. How does regular participation in Forest School contribute to the development of children's science process skills?

RQ5. How do families perceive the educational impact of participation in the Forest School project?

By adopting a longitudinal and multi-perspective approach, this study contributes new evidence regarding the implementation of a Forest School model within mainstream public ECE and its potential to support learning environments, children's play, science process skills, environmental attitudes, and family engagement with nature.

2. Materials and Methods

2.1. Research Design

This study adopted a longitudinal design combining quantitative and qualitative methods to examine the educational impact of a Forest School pilot project implemented in three ECE settings in the Basque Country (Northern Spain). This design was selected because the research questions addressed both measurable educational outcomes (e.g., play behaviours and environmental attitudes) and participants' experiences and perceptions, requiring the

integration of quantitative and qualitative evidence. Quantitative and qualitative data were collected concurrently throughout one academic year to investigate multiple educational outcomes, including learning environments, children's play, environmental attitudes, science process skills, social interactions, and family perceptions. The different sources of evidence were analyzed separately and integrated during interpretation to provide a comprehensive understanding of the educational impact of the Forest School project.

The study was conducted during the 2018–2019 academic year within a mixed educational model combining conventional classroom instruction with regular sessions in nearby forest environments. Unlike full-time Forest School, this model integrated nature-based learning within mainstream public schooling through systematic and repeated outdoor sessions connected to curricular objectives.

2.2. Educational Context and Participants

Three public ECE schools participating voluntarily in the Forest School pilot project were included in the study. The schools represented urban, semi-urban, and rural educational contexts within Gipuzkoa. The participating groups included two classrooms from an urban public school (46 children aged 5 years), two classrooms from a semi-urban school (40 children aged 4 years), and one mixed-age classroom from a rural school situated in a rural area (20 children aged 2–5 years). In total, 106 children and three classroom teachers, one from each participating school, participated in the study.

The three schools differed considerably in their sociogeographical and educational contexts. The urban school was located in the center of a city (approximately 214,000 inhabitants), within a historic building characterized by limited outdoor natural space and high linguistic and cultural diversity among students. The semi-urban school was located in a smaller town (approximately 20,000 inhabitants), where some students also came from nearby rural environments. Finally, the rural school was situated in a mountainous area with fewer than 400 inhabitants, surrounded by forests and natural landscapes. Children attending the rural school generally had greater familiarity with nearby natural environments than children from urban contexts.

The implementation frequency of the Forest School model also differed between schools. During the pilot phase, children from the urban and semi-urban schools attended forest school sessions intensively for one week each month, followed by approximately three weeks in their usual school. By contrast, children from the rural school participated in weekly forest sessions throughout the academic year.

2.3. Forest School Intervention

Despite contextual differences, all schools followed a similar pedagogical routine during forest school days. Children wore waterproof clothing and carried spare clothes suitable for outdoor activities. Before leaving school, groups collectively prepared materials, discussed the day's activities, reviewed forest rules, and selected student helpers responsible for supporting group organization. Upon arriving at the forest site children and teachers gathered in a circle to discuss safety, coexistence, and respect for nature. In all schools, one child symbolically "asked permission from the forest" before beginning the session, reflecting the project's relational and care-oriented pedagogical approach toward the natural environment.

Forest school sessions generally began with a guided proposal connected to curricular objectives, followed by approximately two hours of child-led free play and exploration. During free play, teachers systematically observed children's interactions, interests, conflicts and science processes while documenting relevant observations related to learning and development. Sessions usually concluded with a closing circle discussion in which children

and teachers collectively reflected on experiences, discoveries, and observations from the day.

2.4. Learning Environments

To reduce environmental variability during observations, all measurements were conducted repeatedly within the same forest and school environments throughout the study period.

The forest school environments corresponded to the temperate Atlantic mixed forest biome characteristic of Northern Spain. These ecosystems were characterized by deciduous vegetation, uneven terrain, streams, mud areas, natural shelters, and abundant natural materials. Seasonal climatic variation, frequent rainfall, and dense vegetation generated diverse opportunities for movement, sensory exploration, symbolic play, and interaction with ecological phenomena.

The conventional outdoor environments differed substantially across schools. The urban school playground consisted mainly of a small semi-indoor paved area with limited natural elements. The semi-urban school had a larger playground including grassy areas and uneven terrain. The rural school did not have a conventional playground; instead, children used the town's main public square and surrounding outdoor spaces during school play periods. Figure 1 illustrates examples of the forest school environments and conventional outdoor spaces analyzed in the study.



Figure 1. Photographs of the educational environments analyzed in the study (from top to bottom and left to right). (**A**) Forest area used by the 5-year-old children from the urban area, where a small stream can be observed. (**B**) Forest area used by the 4-year-old children from the semi-urban school; the forest shelter used by the children for lunch and rest periods is also visible. (**C**) Forest area used by the mixed-age group (2–5 years) from the rural school; the teacher is leading the closing circle discussion at the end of the session. (**D**) Playground of the urban school; (**E**) playground of the semi-urban school; and (**F**) the main town square used as the outdoor play space by the rural school.

2.5. Data Collection Instruments

The evaluation framework and several of the data collection instruments used in this study were previously developed and described within the educational evaluation model designed for this pilot project (Sanz et al., 2018). The original framework aimed to assess multiple dimensions associated with children's regular interaction with natural environments, including environmental suitability, free play, environmental attitudes, cognitive and affective development, and science process skills (Table 1).

Table 1. Overview of the evaluation dimensions, instruments, participants, and observation contexts.

Research Question	Outcome Variable	Instrument	Participants	Data Collection
RQ1	Learning environments	Adapted ECERS scale (Harms et al., 2006) and direct environmental observation (Corraliza & Collado, 2011)	106 children	September–June
RQ2	Play and social interactions	POS scale (Rubin, 1989) and EELPCI scale (Laevers, 2005) and adapted ECERS indicators (Harms et al., 2006)	106 children	September–June
RQ3	Environmental attitudes	NEP-based interview (Manoli et al., 2007)	30 children	Autumn–Spring
RQ4	Science process skills	Teacher observation protocol based on science process skills (Martin et al., 2005; NGSS, 2013)	3 teachers	Every 40 days
RQ5	Family perceptions	Family questionnaire (O'Brien & Murray, 2007)	90 families	June

The instruments employed in this study comprised standardized instruments (e.g., the ECERS-R and the NEP Scale for Children) as well as structured observational frameworks (e.g., the Play Observation Scale and the Leuven Involvement Scale). Where standardized instruments were adapted, their conceptual structure and validated dimensions were retained while the wording, selected dimensions, or administration procedures were modified to suit the developmental characteristics of young children and the Forest School context. Because these observational instruments rely on structured behavioural coding rather than internal consistency among questionnaire items, reliability was ensured through observer training, the use of shared coding criteria, pilot observations, and consensus coding between two independent observers.

The physical, material, and social characteristics of forest and playground environments were assessed using adapted environmental observation scales based on the Early Childhood Environment Rating Scale, a standardized observational instrument with established validity and reliability for evaluating early childhood educational environments (Harms et al., 2006; Laevers, 2005). Rather than applying the complete ECERS-R, the instrument focused on dimensions considered particularly relevant to Forest School settings, including gross motor opportunities, physical and material characteristics, natural environment characteristics, free play conditions, and opportunities for social interaction. These dimensions were selected to evaluate the educational affordances of both forest and conventional playground environments while maintaining the observational framework of the original ECERS-R (Sanz et al., 2018). Observations were conducted repeatedly throughout the academic year in both forest and school playground contexts.

Children's social and cognitive play behaviors were analyzed through systematic observation protocols adapted from Parten's social participation categories (Parten, 1932) and Rubin's Play Observation Scale (Rubin, 1989). Social play categories included solitary, parallel, and group play, while cognitive play categories included functional, constructive, symbolic, and rule-based play. Observational records were collected during free play periods in both forest and playground settings.

Children's environmental attitudes were explored through semi-structured interviews adapted to ECE contexts and inspired by the New Ecological Paradigm (NEP) Scale for Children developed by Manoli et al. (2007). The original instrument was developed

through a two-year validation process involving pilot testing, exploratory factor analysis, and confirmatory factor analysis, resulting in a validated 10-item instrument organised into three dimensions (Rights of Nature, Eco-Crisis, and Human Exemptionalism). In the present study, the conceptual dimensions of the original instrument were retained while the administration format was adapted into a semi-structured interview appropriate for early childhood participants. Interview questions focused on children's perceptions of plants, animals, forests, and ecological relationships. Particular attention was paid to identifying anthropocentric and ecocentric patterns in children's responses throughout the academic year. Anthropocentric responses reflected views that prioritised human needs and interests, whereas ecocentric responses reflected recognition of the intrinsic value of living organisms and ecosystems regardless of their usefulness to humans (Himes et al., 2024).

Semi-structured interviews were conducted with participating teachers at different moments during the project. Interviews explored pedagogical practices, perceptions of children's learning, science process skills, science-related experiences, social dynamics, and challenges associated with forest school implementation. All interviews were audio-recorded and transcribed for analysis.

Finally, at the end of the academic year, families completed a questionnaire regarding their perceptions of the educational impact of the project. The questionnaire included closed and open-ended questions addressing environmental awareness, motivation, autonomy, physical development, concentration and family engagement with outdoor activities.

2.6. Procedure

Data collection was conducted longitudinally throughout the 2018–2019 academic year, from September to June following the schedule presented in Figure 2. Learning environment observations, play and social interaction observations, and complementary field notes were recorded immediately after each observation session in structured observation logs. Children's environmental attitude interviews were conducted at three time points (November, February, and May), teacher interviews were carried out approximately every 40 days following Forest School sessions, and family questionnaires were administered at the end of the academic year.

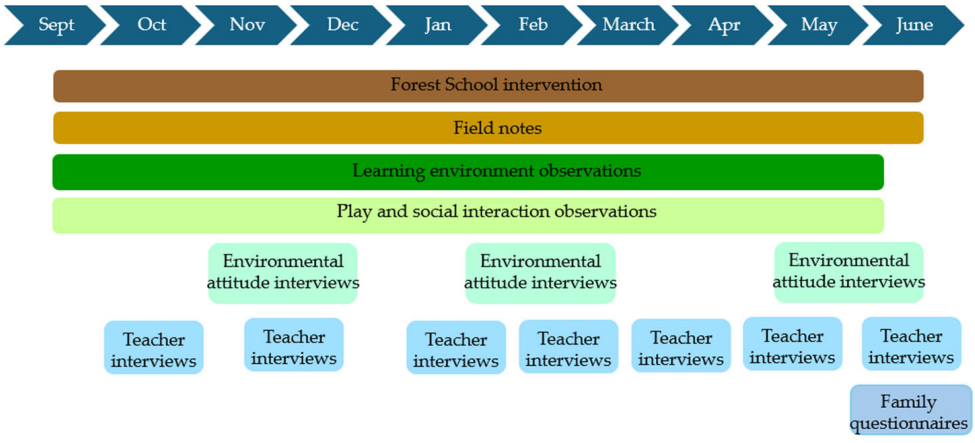


Figure 2. Timeline of the Forest School intervention and longitudinal data collection throughout the 2018–2019 academic year.

Five researchers from Kutxa Ekogunea and two university researchers were involved in different phases of this investigation, whereas the principal researcher attended approximately 90% of the forest school sessions throughout the study period and carried out or was involved in repeated observations in both forest and school contexts. This pro-

longed engagement facilitated in-depth familiarity with children's behaviors and supported contextual comparison across educational environments.

Researchers systematically collected data associated with each evaluation instrument while also recording complementary field notes regarding children's interactions, science process skills, conflicts, environmental engagement, and relevant contextual situations. All observational records were anonymized to ensure participant confidentiality.

Environmental observations, play observations, and interaction analyses were conducted during free play periods because these moments provided opportunities to observe children's autonomous interactions, symbolic play, environmental exploration, science process skills, and peer relationships across contexts. During environmental and interaction observations, the first 30 min were used for contextual familiarization before systematic observation began. Additional field notes were completed after observation sessions to document events and interactions that could not be fully recorded in real time.

For the analysis of children's social and cognitive play behaviours, systematic observations were conducted approximately 30 min after the beginning of free play, as previous research has suggested that children often require an initial adaptation period before becoming fully engaged in play activities (Ward, 1994). Children's play was observed within the whole class during each Forest School session, involving a total sample of 106 children (46 from the urban school, 40 from the semi-urban school, and 20 from the rural school). To enable systematic behavioural recording, a rotating focal-child sampling strategy was adopted. During each observation session, three children from each participating school were randomly selected for detailed observation. Across successive sessions throughout the academic year, all participating children were included repeatedly in the focal observations, allowing behavioural data to be collected from the entire cohort while maintaining a manageable observation protocol. Each observation lasted between 2 and 5 min and focused on social interactions, play duration, materials used, environmental engagement, motivational patterns, and inquiry-related behaviours. Observation points were selected to ensure visibility of the entire group whenever possible. No additional groups were present in the observation environments during data collection sessions. All observations were conducted independently by two researchers using the same structured observation protocol. Before data collection, both observers jointly reviewed the observation categories and pilot-tested the protocol to ensure a shared understanding of the coding criteria. After each observation session, coding discrepancies were discussed until agreement was reached, and the agreed dataset was subsequently analysed by the research team. Because an independent inter-rater reliability coefficient was not calculated, no numerical agreement index is reported.

Play observations were conducted using an adapted version of Rubin's Play Observation Scale (Rubin, 1989), which combines social play categories derived from Parten's model (Parten, 1932) with cognitive play categories inspired by Piagetian developmental theory (Piaget, 1962). Social play categories included solitary, parallel, and group play, while cognitive play categories included functional, constructive, symbolic, and rule-based play. Solitary play referred to situations in which children played independently, generally at least one metre from their peers, using different materials and showing little attention to others' activities. Parallel play described children playing individually while remaining close to peers, often using similar materials and occasionally attending to or commenting on each other's activities. Group play referred to cooperative play in which children shared a common goal, such as jointly constructing a structure or developing a shared play scenario.

Cognitive play was classified into four categories. Functional play involved simple physical or motor activities performed without an explicit constructive goal (e.g., climbing trees, pouring water between containers, singing, or running). Constructive play referred

to the purposeful manipulation of materials to create or build something. For example, handling mud for sensory exploration was coded as functional play, whereas intentionally making "mud sausages" or constructing objects with mud was classified as constructive play. Symbolic play involved role-playing, pretending, or assigning symbolic meanings or human characteristics to objects or living beings. Rule-based play referred to games governed by mutually agreed rules that constrained children's actions, such as deciding that a game ended if a passed stone touched the ground.

Environmental attitude interviews were conducted individually with a subsample of 30 randomly selected children (5 boys and 5 girls from each participating school) and lasted approximately 15 min each. Questions were adapted to children's developmental levels through conversational prompts and references to familiar everyday experiences to facilitate responses and encourage participation. Interviews focused on children's perceptions of plants, animals, forests, and ecological relationships, with particular attention to anthropocentric and ecocentric perspectives.

Interviews with teachers regarding children's environmental knowledge, science process skills, and learning experiences were conducted approximately every 40 days following forest school sessions. Family questionnaires were distributed digitally through Google Forms at the end of the academic year.

2.7. Data Analysis

Quantitative data were analysed using SPSS (Version 22). Descriptive statistics were calculated for all quantitative variables. Comparisons between Forest School and conventional school environments based on the adapted ECERS were performed using paired Wilcoxon signed-rank tests because the environmental ratings were paired by school and based on an ordinal rating scale. Differences in children's play behaviours between settings were also analysed using paired Wilcoxon signed-rank tests, as observations were conducted on the same classes in both environments. Statistical significance was established at $p < 0.05$.

Qualitative observational records, teacher interviews, and family responses were analyzed using a reflexive thematic analysis approach (Braun & Clarke, 2006). Initial codes were generated inductively from repeated readings of the data and subsequently organized into broader thematic categories aligned with the research questions. Initial coding was conducted independently by the researchers and subsequently discussed collaboratively until interpretative consensus was reached. The integration of quantitative and qualitative data enabled triangulation across multiple sources of evidence and supported a more comprehensive understanding of children's experiences within the forest school project.

2.8. Ethical Considerations

The study was conducted in accordance with institutional and national ethical guidelines for educational research involving human participants. Participation was voluntary, and informed consent was obtained from participating schools, teachers, and families prior to data collection. All data were anonymized to ensure participant confidentiality and privacy. Because the study involved non-invasive educational observations conducted within ordinary school activities, no intervention beyond routine educational practice was introduced.

2.9. Data Availability and Use of Generative Artificial Intelligence

Parts of the evaluation framework and selected preliminary findings from the pilot project were previously presented in conference proceedings associated with the Psychodidactics Research Conference (Sistiaga & Sanz, 2025). The present study substantially expands this earlier dissemination.

The datasets generated and analyzed during the current study are not publicly available due to ethical and privacy restrictions involving minors but may be made available from the corresponding author upon reasonable request and with institutional permission, in accordance with data protection regulations and MDPI research data policies.

Generative artificial intelligence tools were used exclusively for linguistic revision, translation support, and academic language refinement during manuscript preparation. All conceptual development, data collection, analysis, interpretation, and final content revision were conducted by the authors, who take full responsibility for the content of this publication.

3. Results

This section follows the rationale of the research questions, including the physical and material characteristics and the natural characteristics of the learning environments (RQ1), the socio-cognitive dimensions of play and the student–teacher and peer relationships (RQ2), environmental attitudes (RQ3), science process skills and (RQ4) and the family perceptions (RQ5).

3.1. Physical and Material Characteristics of the Learning Environments

Seven ECERS-R items related to the physical and material environment were analyzed in the present study: (1) opportunities for gross motor activity; (2) health practices; (3) safety practices; (4) construction materials; (5) sand and water play; (6) nature and science resources; and (7) free play conditions. The main results are presented in Figure 3.

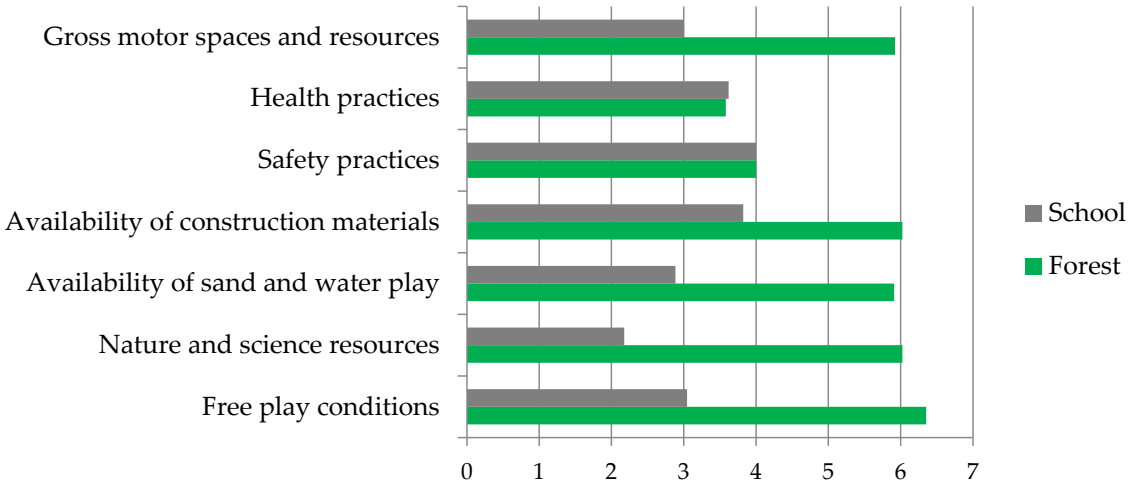


Figure 3. Comparison of the physical and material characteristics of forest school and conventional outdoor school environments according to the adapted ECERS scale. Mean scores across the participating schools are presented.

Forest school environments consistently obtained higher mean scores for opportunities for gross motor activity, availability of construction materials, sand and water play, nature and science resources, and free play conditions. Paired Wilcoxon signed-rank tests indicated very large effect sizes for these dimensions (rank-biserial correlation = 1.00), although none of the comparisons reached conventional statistical significance (all $p = 0.057–0.058$). No substantial differences were identified regarding health or safety practices.

The forest environments provided diverse opportunities for climbing, balancing, running, manipulating natural elements, and moving across uneven terrain. Children additionally had continuous access to open-ended natural materials such as sticks, stones, mud, leaves, branches, and water, which supported both exploratory play and science inquiry-based activities throughout the academic year.

Science-related exploration also emerged frequently during forest sessions. Through direct interaction with ecological and physical phenomena, children engaged in observation, comparison, experimentation, and communication processes associated with early inquiry-based science learning. Teachers incorporated simple inquiry-supporting materials such as magnifying glasses, ropes, containers, and field guides, encouraging children to investigate weather conditions, biodiversity, water movement, and material transformations through embodied experience.

Another relevant difference concerned the organization of free play. Forest sessions generally included longer and more autonomous periods of child-led exploration, during which teachers adopted primarily observational and facilitative roles while documenting children's interests, interactions, and science process skills.

Taken together, the findings indicate that nearby forest environments functioned not only as alternative outdoor spaces, but also as materially rich pedagogical contexts supporting movement, exploratory play, inquiry-based science processes and sustained interaction with natural phenomena.

3.2. Natural Characteristics of the Educational Environments

Forest School environments consistently received higher scores for the natural characteristics of the educational environment than conventional school outdoor spaces (Forest: $M = 6.40$; School: $M = 2.60$). Although the paired comparison did not reach conventional statistical significance (Wilcoxon signed-rank test: $W = 15.0$, $p = 0.057$), the effect size was very large (rank-biserial correlation = 1.00). Forest school environments were characterized by a high diversity of natural elements, with vegetation and natural surfaces representing more than 90% of the available space. These environments included diverse ecological features such as trees, shrubs, grasslands, streams, mud areas, and woodland vegetation that were regularly used for educational activities and free play throughout the academic year.

By contrast, conventional playgrounds showed substantial variability across schools. In the most favorable cases, green areas represented approximately 15% of the total outdoor space. Although some schools included isolated natural elements or school gardens, these spaces were generally smaller and less integrated into everyday educational practices.

3.3. Social and Cognitive Dimensions of Play

Children's play behaviors were analyzed from both social and cognitive perspectives. Social play observations focused on solitary, parallel, and group play, while cognitive play categories included functional, constructive, symbolic, and rule-based play. Across the academic year, group play progressively increased during forest school sessions, while solitary play decreased over time (Figure 4). When all observations were considered together, collaborative forms of play occurred more frequently in forest environments, whereas solitary play appeared more commonly during conventional playground sessions.

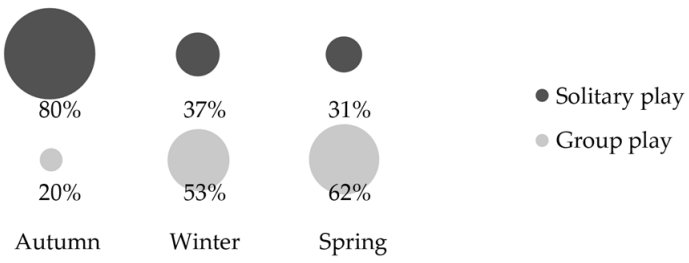


Figure 4. Evolution of play behaviors during forest school sessions throughout the academic year. Percentages of solitary and group play observed during forest school sessions across the three observation periods.

Regarding cognitive play, children engaged in a wide variety of exploratory and imaginative activities across both contexts. However, the analyses indicate a shift in the organisation of play between settings. Solitary constructive (p = 0.020), solitary symbolic (p = 0.014), and parallel constructive play (p = 0.022) occurred more frequently during playground observations. Group symbolic play was more frequent during Forest School sessions (p = 0.047), whereas group constructive play showed a marginal difference (p = 0.050). No significant differences were observed for the remaining play categories (Figure 5).

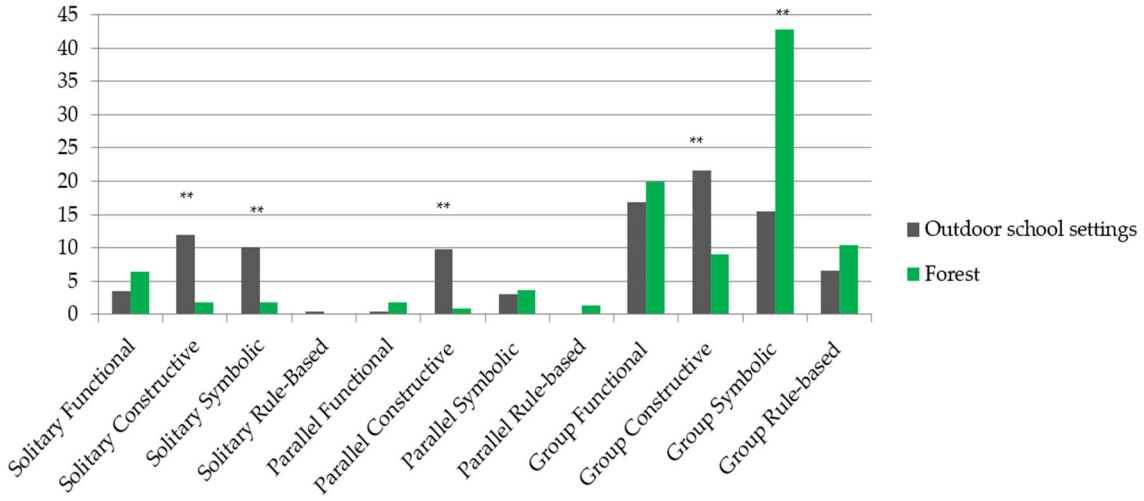


Figure 5. Mean frequencies of combined social and cognitive play categories observed across the 106 participating children. ** $p < 0.05$.

Children frequently transform natural materials and spaces into imaginary scenarios, shelters, fictional landscapes, and role-playing situations. Sticks, stones, leaves, mud, and uneven terrain simultaneously functioned as imaginative resources, construction materials, and objects of inquiry. Finally, differences in symbolic play episodes were also observed between urban and rural children's play narratives and relationships with nature. Rural children more frequently incorporated locally meaningful activities into their play, such as woodcutting with axes, hunting practices, or other land-based activities familiar within their community contexts. In contrast, urban children showed a greater tendency to anthropomorphize animals and natural elements, engaging in nurturing and caregiving behaviors. For example, children were observed cleaning a pig with wet wipes after it had defecated or assigning human characteristics, emotions, and intentions to animals encountered during forest sessions.

3.4. Student–Teacher and Peer Relationships

Student–teacher relationships and peer interactions were analyzed using adapted ECERS interaction indicators. Positive student–teacher relationships were consistently observed across all participating schools. Teachers promoted respectful communication, emotional support, participation, and collaborative decision-making in both educational contexts (Figure 6).

More substantial differences emerged regarding peer interactions. During forest school sessions, interactions among children were predominantly cooperative and characterized by shared play, collaborative exploration, and relatively low levels of conflict. Children frequently participated autonomously in group activities while respecting shared materials and agreed coexistence rules.

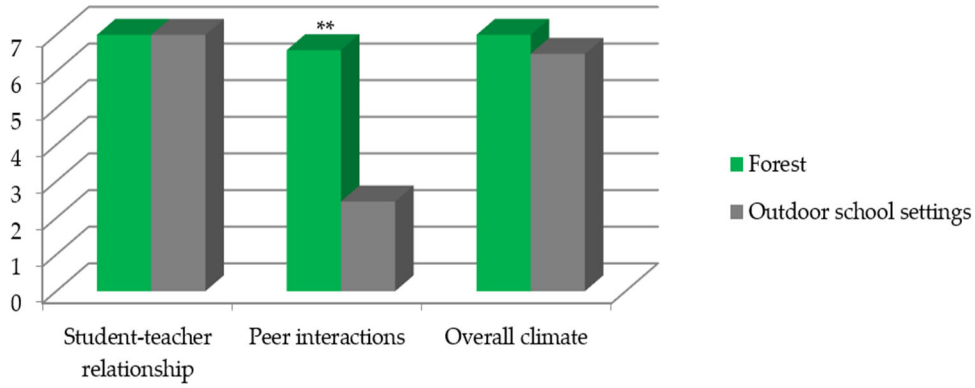


Figure 6. Comparison of student–teacher relationships and peer interactions in forest school and conventional playground environments measured using adapted ECERS indicators. Mean scores across the participating schools are presented. ** $p < 0.05$.

Forest sessions additionally showed calmer group dynamics overall. Noise levels were generally lower, teachers rarely needed to raise their voices, and children remained engaged for extended periods in play and inquiry-related activities. High levels of motivation and sustained involvement were observed throughout the academic year.

Although conventional playgrounds also presented generally positive social environments, they showed comparatively higher frequencies of conflict, behavioral interruptions, and adult intervention. Examples recorded in the field notes included disputes over access to playground equipment or materials, interruptions caused by disagreements about turn-taking, and situations requiring adult intervention to resolve conflicts between children. The findings suggest that repeated participation in forest school sessions supported collaborative peer relationships and autonomous interaction during ECE.

3.5. Environmental Attitudes and Ecocentric Behaviour

Children's environmental attitudes were analyzed by categorizing their responses as predominantly anthropocentric or ecocentric. Across the academic year, the findings revealed a progressive shift toward more ecocentric perspectives during participation in the forest school project (Figure 7).

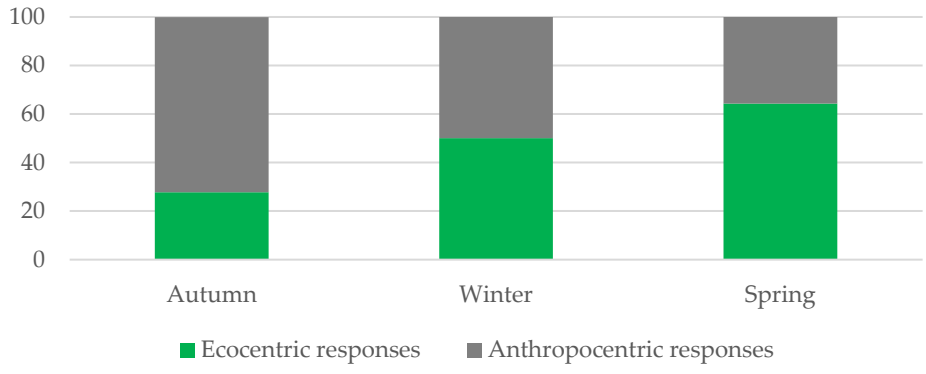


Figure 7. Percentages of anthropocentric and ecocentric responses provided by 30 children during the autumn, winter, and spring assessment periods.

This attitudinal evolution was also reflected in children's behaviors and emotional relationships with living organisms and natural environments. During the initial observation periods, behaviors such as stepping on insects, handling small animals carelessly, or attempting to take natural elements home were relatively common. However, by the end of the academic year, children demonstrated greater empathy toward living beings and

stronger expressions of environmental care. For example, when children encountered dead animals in the forest, they frequently expressed sadness and organized symbolic burial rituals collectively.

Finally, children's responses were also influenced by their sociocultural and environmental contexts. Children from rural backgrounds more frequently framed nature in relation to human use and everyday practical functions. On the one hand, examples of ecocentric responses included: "*Trees are important because they give life to people and animals*" and "*We cannot live without trees because they give oxygen*." On the other hand, examples of anthropocentric responses included: "*Trees are important because they give us fruit*" or "*Plants are important because they give medicine when children are sick*."

3.6. Science Process Skills and Environmental Knowledge

Periodic interviews conducted with teachers were used to assess both children's environmental knowledge (scientific content) and the development of science process skills (Table 2). Although free play represented a central component of the forest school methodology, teachers consistently promoted observation, exploration, communication, representation, and reflection through direct interaction with natural materials, animals, plants, and ecological phenomena. Compared with previous academic years in the same schools, teachers reported that children engaged with a broader range of scientific content and inquiry processes during the forest school pilot project. In many cases, teachers described learning experiences as extending beyond the predominantly observation-based activities typically implemented in previous classroom practice.

Table 2. Science process skills developed during the Forest School Project (green dots) and in previous academic years at school (black dots).

Scientific Content Areas	Observe	Classify, Measure, Compare	Experiment	Represent	Communicate
Living beings					
Characteristics	●●	●●		●●	●●
Needs	●	●	●	●	●
Life cycles	●	●		●	●
Biodiversity	●	●		●	●
Habitat	●	●		●	●
Earth Sciences					
Water cycle	●●		●		●
Weather	●●	●●			●●
Earth–Sun system	●●			●●	●●
Matter					
Changes in state	●	●	●		●
Rock diversity and classification	●	●		●	●
Mixtures (mud, water, colours…)	●	●	●	●	●
Temperature and seasonal patterns	●●	●●		●	●●
Forces and movement					
Balance and movement	●	●	●		●
Construction (blocks, shelters…)	●●	●●	●●		●●

Living beings represented the most extensively explored scientific topic. Through repeated interaction with plants, animals, fungi, and ecological processes, children investigated questions related to movement, feeding, habitats, decomposition, biodiversity, and life cycles. Daily encounters with living organisms encouraged children to compare themselves with other species and formulate inquiry-based questions such as: "*What do they eat?*", "*How do they move?*", and "*Does a tree without leaves mean it is dead?*".

The discovery of dead animals additionally enabled long-term observation of decomposition processes and ecological change. Whereas previous classroom-based approaches

had mainly focused on identifying characteristics and habitats of living beings, the forest school experience facilitated exploration of biological needs, life cycles, biodiversity, and ecological interdependence. Teachers also reported that children became increasingly capable of representing and communicating their understanding of living organisms and ecological relationships.

Substantial differences emerged regarding Earth science learning. Teachers explained that, in previous academic years, weather-related activities in school contexts had primarily involved observing and comparing daily or seasonal weather conditions. By contrast, during forest school sessions, children explored, represented, and communicated seasonal and meteorological changes through direct embodied experience. For example, children connected weather conditions to bodily sensations and environmental transformations, stating: "*In winter, when it rains, we get colder faster and they give us warm drinks*."

The water cycle represented another topic that emerged directly from interaction with natural environments. Although this topic had not previously been addressed systematically in classroom contexts, forest environments enabled children to observe freezing, melting, evaporation, puddle formation, stream creation, and changes in water movement through direct experimentation and inquiry. Children communicated these observations using explanations such as: "*The puddles froze because it is cold*" or "*When it does not rain, the puddles disappear*."

Forest school environments also supported exploration of material properties and physical processes through interaction with mud, water, sticks, stones, and other natural materials. Through collaborative experimentation and play, children explored concepts related to density, balance, force, volume, and material transformation. Teachers additionally reported the integration of early mathematical reasoning through activities such as measuring stream depth with sticks or filling containers with different quantities of water and mud.

One particularly distinctive inquiry experience occurred in the rural school, where children systematically documented lunar phases through daily observation and photography to answer the children's question "*Why do we sometimes see the Moon during the day?*". Children observed the Moon at the same time each morning, recorded its position relative to the town square, and later represented these observations collectively through visual displays and classroom discussions.

Finally, the availability of open-ended natural materials facilitated exploration of physical concepts such as balance, force, and stability through activities including shelter construction, movement across uneven terrain, and the creation of simple catapult-like structures.

Teachers consistently described nearby forest environments as providing opportunities for inquiry-based science learning and for the development of science process skills during ECE. Forest experiences enabled children to observe, explore, compare, represent, communicate, and discuss scientific ideas through direct interaction with natural phenomena.

3.7. Family Perceptions of the Forest School Experience

Based on the framework proposed by O'Brien and Murray (2007), families were asked at the end of the academic year to evaluate the perceived impact of the forest school project across different developmental domains (Figure 8).

A total of 90 families completed the questionnaire. Only 14.4% of respondents reported not perceiving noticeable changes in their children, whereas 81.1% identified positive developmental changes that they associated with their children's participation in the Forest School pilot project.

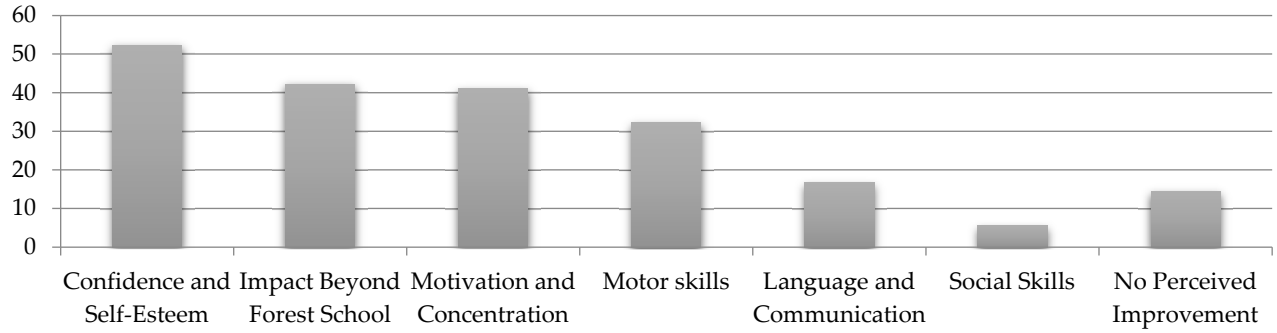


Figure 8. Family perceptions of the developmental impacts of the forest school project.

The area in which families most frequently perceived improvement was knowledge and understanding. Approximately 60% of families reported increased environmental awareness, greater respect for nature, and heightened interest in nearby ecosystems and natural phenomena. Families additionally observed that children more frequently discussed weather conditions, seasonal changes, plants, animals, and environmental processes in everyday conversations, while also demonstrating improved ability to identify different flora and fauna species.

Substantial improvements were also perceived regarding motivation and concentration. Approximately 41.1% of families reported that children demonstrated more positive attitudes toward learning, exploration, inquiry-related science processes, and play activities following participation in forest school sessions. Families additionally described increased capacity for sustained attention, task engagement, and concentration during both play and learning activities.

Physical development represented the third most frequently identified area of improvement. Approximately 32.2% of families reported improvements in children's gross and fine motor abilities, body awareness, balance, and movement skills in natural environments. Families particularly highlighted children's increased confidence navigating uneven terrain, climbing, balancing, manipulating natural materials, and engaging physically with outdoor environments.

Regarding confidence and autonomy, 24.4% of families perceived improvements in children's self-esteem, while 27.8% reported increased independence and autonomy in everyday activities.

Lower percentages were identified regarding language development and social skills. Approximately 16.7% of families reported improvements in oral language sophistication and communication, whereas only 5.5% perceived substantial changes in social behavior such as cooperation, material sharing, or participation in collaborative play.

Finally, 42.2% of families reported that the forest school experience extended beyond the school context and influenced family routines at home. According to parents, children's enthusiasm for Forest School activities encouraged more frequent visits to natural environments and greater family engagement with outdoor experiences.

4. Discussion

The present study explored the educational potential of forest school experiences in ECE from the perspective of inquiry-based science learning, environmental relationships, play, and sustainability-oriented pedagogies. The findings indicate that repeated interaction with nearby natural environments provided opportunities for children to engage in science process skills, collaborative exploration, environmental awareness, and care-oriented relationships with living systems. These findings are consistent with previous research highlighting the educational value of outdoor and nature-rich pedagogies

in early childhood contexts (Askerlund et al., 2022; Harris, 2025; Kiviranta et al., 2024; VanLone et al., 2024). The project was additionally shaped by local place-based educational traditions and by the cultural relevance of nearby natural environments within Basque educational contexts.

One of the most significant findings concerns the role of nearby ecosystems in supporting inquiry-based science learning during early childhood. Children engaged in sustained processes of observation, comparison, experimentation, representation, and communication through direct interaction with ecological and physical phenomena. Rather than approaching scientific concepts primarily through symbolic classroom instruction, children explored weather changes, decomposition, biodiversity, water movement, freezing and melting, and material transformation through embodied and collaborative experiences. These findings reinforce previous perspectives suggesting that young children develop scientific understanding most meaningfully through active inquiry situated within familiar and contextually relevant environments (Barrable & Booth, 2020; Cutter-Mackenzie et al., 2014). Importantly, the forest school environment functioned as an interdisciplinary STEM context in which science inquiry, engineering design, mathematical reasoning, and collaborative problem solving emerged through children's everyday interactions with natural materials.

The findings additionally suggest that inquiry-based science learning and environmental care developed in interconnected ways throughout the project. Across the academic year, children progressively demonstrated more ecocentric interpretations of nature and greater empathy toward living organisms. These changes became visible not only in children's interview responses, but also in their everyday behaviors and interactions with animals, plants, insects, and natural materials. Previous research has similarly emphasized that repeated emotional and sensory engagement with nearby ecosystems may foster environmental sensitivity and ecological identity during childhood (Chawla, 2020; Sobel, 2004). In the present study, teachers and observations suggested increasing environmental care through sustained opportunities to explore, observe, and emotionally connect with living systems rather than through explicit environmental instruction alone (Askerlund et al., 2022).

Taken together, these findings are consistent with contemporary perspectives in Education for Sustainable Development (ESD), which emphasise the importance of repeated, meaningful experiences in nature for fostering environmental awareness, caring relationships with living systems, and opportunities for active engagement with ecological phenomena (Davis & Elliott, 2014). Rather than demonstrating direct causal effects, the present findings suggest that Forest School may provide a supportive context in which these educational processes can emerge during early childhood. The study also highlights the importance of play as a mediating process connecting inquiry, collaboration, and environmental exploration. Compared with conventional playground contexts, forest environments supported more collaborative forms of symbolic play, longer periods of autonomous activity, and lower levels of conflict. Natural materials simultaneously functioned as scientific objects, imaginative resources, and tools for experimentation, allowing children to move fluidly between inquiry, storytelling, construction, negotiation, and collective meaning-making. These findings align with previous research emphasizing the importance of guided play and open-ended exploration within early STEM learning (Cutter-Mackenzie et al., 2014), as stated by Siry et al. (2023), that inquiry through play is the basis of scientific thinking. In this sense, the study suggests that scientific inquiry during early childhood may emerge not only through structured instructional activities, but also through collaborative play and exploratory interaction with complex natural environments. Also in nature these play pedagogies may support better science learning, as when involved

in play children may be given sufficient time for social interaction, for exploration and for discussion of ideas with peers and with adults (Johnston & Campbell, 2021).

The social and emotional dimensions of the forest school experience also deserve attention. Compared with conventional playground settings, forest sessions promoted lower noise levels, and more cooperative and calmer peer interactions. Children participated more frequently in autonomous group activities and required less adult behavioral intervention during play and inquiry-based processes. These findings are consistent with previous studies indicating that nature-rich environments may support socio-emotional well-being, self-regulation, cooperation, and positive peer relationships during childhood (Brussoni et al., 2017; Dankiw et al., 2020). From a sustainability-oriented perspective, these results are particularly relevant because they suggest that social coexistence and environmental relationships may develop simultaneously through shared engagement with natural spaces and collective exploration.

Family perceptions additionally reinforce the broader educational significance of the project. Families identified improvements not only in environmental awareness and motivation toward learning, but also in concentration, autonomy, physical competence, and engagement with outdoor experiences beyond school contexts. Particularly relevant is the finding that many families described transferring the forest school experience into everyday family routines through increased use of natural environments and outdoor activities. Similar findings have been reported in previous sustainability education research emphasizing the importance of family–school relationships in supporting long-term environmental engagement and nature connectedness (Barrable & Booth, 2020; Ernst & Tornabene, 2012). These results suggest that sustainability-oriented pedagogies in early childhood may influence not only children's learning experiences within school, but also broader ecological practices and relationships within family and community life.

The study additionally raises important questions regarding contextual diversity in environmental and sustainability education. As in the case of some studies that highlighted the difference in a different approach to nature of rural-residing teachers (Pedonti et al., 2025) some differences were observed between urban and rural children's environmental responses suggesting that children's relationships with nature are strongly shaped by sociocultural context and everyday lived experiences. For example, some children of the rural-context responses (20) revealed a certain utilitarianism of the natural environment and living beings, something we assume they have seen in their family context. Consequently, sustainability education should avoid assuming homogeneous understandings of nature and instead recognize the diversity of children's environmental imaginaries, practices, and ecological relationships. These findings reinforce the importance of place-responsive pedagogies capable of connecting science process skills with children's local environments and cultural contexts.

Despite these contributions, several limitations should be acknowledged. First, the study focused on a relatively small number of schools located within a specific geographical and cultural context in Northern Spain. Second, although the longitudinal design strengthened the analysis of behavioral and attitudinal changes over time, some findings relied partially on teacher and family perceptions. Future research could incorporate larger comparative samples, longitudinal follow-up studies, and additional child-centered assessment tools to further explore the long-term effects of forest school experiences on science learning, sustainability competencies, and environmental attitudes.

Future research should also examine how inquiry-based outdoor pedagogies may contribute to broader sustainability competencies during early childhood, including systems thinking, ecological reasoning, collaborative problem solving, and environmental action competence. Additional attention should be given to teacher professional development,

particularly regarding inquiry facilitation, outdoor science education, and sustainability-oriented pedagogies in ECE. Recent discussions in early childhood STEM education additionally emphasize the importance of supporting educators in recognizing and scaffolding children's spontaneous scientific inquiries within playful and everyday contexts. For example, when preservice teachers are trained in nature-based pedagogy there is an increase in participants' knowledge of nature-based pedagogy and teacher self-efficacy (VanLone et al., 2024) but it also has transformative benefits and personal shifts in their connections to nature (Cetken-Aktas et al., 2025).

The findings suggest that forest school experiences may provide meaningful contexts for connecting curiosity, inquiry, science learning, and environmental care during the early years. Rather than functioning solely as alternative outdoor learning spaces, nearby natural environments appeared to operate as relational pedagogical contexts in which curiosity, inquiry, scientific thinking, play, and environmental care became deeply interconnected through everyday embodied experience.

5. Conclusions

This study explored the educational potential of forest school experiences within mainstream ECE from the perspective of inquiry-based science learning, play, environmental relationships, and sustainability-oriented pedagogies. Overall, the findings suggest that repeated interaction with nearby natural environments may support interconnected developments across curiosity-driven exploration, science process skills, and care-oriented relationships with living systems.

Rather than functioning solely as alternative outdoor learning spaces, forest environments operated as relational pedagogical contexts in which children engaged simultaneously in observation, experimentation, imaginative play, communication, and collaborative problem-solving through direct interaction with ecological phenomena and open-ended materials. Across the academic year, children additionally developed more empathetic and ecocentric relationships with living beings, while teachers and families identified broader impacts on motivation, autonomy, social interaction, and engagement with the natural world beyond school contexts.

The findings reinforce contemporary perspectives in early childhood STEM and sustainability education that conceptualize learning as interdisciplinary, embodied, and place-responsive (Ng et al., 2022). Early STEM learning emerged not as isolated disciplinary instruction, but as a process of inquiry, material investigation, representation, and collaborative meaning-making grounded in children's everyday experiences with nearby ecosystems.

Taken together, the study suggests that integrating regular nature-based experiences within mainstream ECE may provide meaningful opportunities to connect curiosity, scientific thinking, and environmental care during the early years. In this sense, nearby natural environments may contribute not only to children's understanding of ecological systems, but also to the development of more relational and sustainability-oriented forms of learning and coexistence.

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PES26/26. The funding body had no role in study design, data collection, analysis, interpretation, or manuscript preparation.

Institutional Review Board Statement: Ethical review and approval were waived for this study because the research consisted of non-invasive educational observations conducted in ordinary school settings without intervention, involving anonymized data collection and minimal risk for participants. The study was conducted in accordance with institutional and national ethical guidelines for educational research, and informed consent was obtained from participating schools and families.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study or from their legal guardians.

Data Availability Statement: The data presented in this study are available on reasonable request from the corresponding author. The data are not publicly available due to ethical and privacy considerations involving minors.

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