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Building Science Learning Environments based on Real-World Experiences and Nature for Preschool Children

Tiep Pham Quang [1*], Nguyen Thi Huong [2]

[1] Vietnam National University, Vietnam, 0009-0005-2760-3885
[2] Thang Long Institute for Educational Science Research and Application, Vietnam, 009-0007-4987-7427
* Corresponding author: Tiep Pham Quang (tiep@vnu.edu.vn)

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Abstract

Early childhood science education has gained increasing recognition as a critical foundation for developing scientific literacy and environmental consciousness. This study investigates the development and implementation of science learning environments based on real-world experiences and nature for preschool children aged 3-6 years in Vietnamese educational contexts. Using a mixed-method approach, we conducted comprehensive research involving 186 participants across 15 kindergartens in three major regions of Vietnam, including structured observations, surveys, and in-depth interviews with educators, parents, and educational experts. Results demonstrate that nature-based science learning environments significantly enhance children's scientific inquiry skills, environmental awareness, and overall cognitive development compared to traditional classroom-based approaches. Children participating in nature-based programs showed 34.7% improvement in scientific observation skills, 28.3% increase in environmental awareness, and 31.2% enhancement in collaborative problem-solving abilities. The main contribution of this research is the development of the "Nature-Integrated Science Learning Environment Model for Vietnamese Preschoolers (NISLE-VN)" with 4 core pillars, specific operational procedures, and implementation conditions suitable for tropical climate, biodiversity, and Vietnamese cultural characteristics. Policy recommendations focus on implementing the NISLE-VN model as a national pilot program, establishing standards and specialized teacher training programs, creating support networks and financial funds for model replication.

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Introduction

Early childhood education, particularly science education for children aged 3-6 years, has emerged as a critical area of educational research and practice worldwide. The foundation for scientific thinking, environmental awareness, and inquiry-based learning is established during these formative years when children's neuroplasticity is at its peak and their natural curiosity about the world around them is most pronounced (Shonkoff & Phillips, 2020). Modern educational research consistently demonstrates that high-quality early childhood science experiences not only foster cognitive development but also contribute to the formation of positive attitudes toward learning, environmental stewardship, and scientific literacy that persist throughout life.

In Vietnam, the rapid economic development and urbanization of recent decades have created both opportunities and challenges for early childhood education. While educational infrastructure has improved significantly, many children, particularly those in urban areas, have limited opportunities for direct engagement with natural environments. This disconnect from nature has been identified by educational researchers and environmental psychologists as a contributing factor to what Richard Louv termed "nature deficit disorder" - a phenomenon characterized by reduced environmental awareness, decreased physical activity, and diminished appreciation for natural systems (Louv, 2019).

The theoretical foundation for nature-based science education draws from multiple educational frameworks, including constructivist learning theory, experiential education, and environmental education principles. Jean Piaget's cognitive development theory emphasizes that children learn best through direct interaction with their environment, constructing knowledge through hands-on experiences and active exploration (Piaget, 2019). Lev Vygotsky's social constructivist approach highlights the importance of social interaction and cultural context in learning, suggesting that collaborative outdoor experiences can provide rich opportunities for peer learning and cultural knowledge transmission (Vygotsky, 2020).

The primary objective of this research is to develop and validate the Nature-Integrated Science Learning Environment Model for Vietnamese Preschoolers (NISLE-VN) - a specific model designed exclusively for the Vietnamese preschool education context. Specific research objectives include: (1) analyzing the current state of science education in Vietnamese kindergartens and identifying opportunities for nature-based approaches; (2) investigating the impact of nature-based science learning on children's cognitive, social, and emotional development; (3) examining the challenges and facilitating factors for implementing nature-based science education; (4) developing the NISLE-VN model with 4 specific pillars, detailed operational procedures, and implementation conditions suitable for Vietnamese conditions; and (5) providing evidence-based policy recommendations for wide-scale model implementation.

Literature Review

Theoretical Foundations of Nature-Based Science Education

Nature-based science education draws from three complementary theoretical frameworks that emphasize active

learning, environmental engagement, and holistic child development. *Constructivist learning theory*, primarily developed by Jean Piaget, posits that children actively construct understanding through direct environmental interaction (Piaget, 2019). This theory is particularly relevant to nature-based education as natural environments provide authentic opportunities for children to observe, experiment, and test hypotheses about natural phenomena through processes of assimilation and accommodation.

Social constructivist theory, articulated by Lev Vygotsky, extends this perspective by emphasizing social interaction and cultural mediation in learning. Vygotsky's Zone of Proximal Development concept suggests children learn best with appropriate support from knowledgeable others (Vygotsky, 2020). Nature-based environments naturally create opportunities for collaborative exploration, peer teaching, and intergenerational knowledge sharing when children work together to investigate habitats, solve environmental problems, or engage in outdoor scientific inquiry.

Experiential learning theory, developed by John Dewey and expanded by David Kolb, provides the framework for authentic, hands-on learning experiences. Dewey's principle that "we learn by doing" emphasizes meaningful learning through direct experience (Dewey, 2018). Kolb's experiential learning cycle—concrete experience, reflective observation, abstract conceptualization, and active experimentation—provides a systematic approach for designing nature-based science activities that progress children through increasingly sophisticated levels of understanding (Kolb, 2021).Together, these theoretical foundations support nature-based science education as an effective approach that combines direct environmental experience with social learning processes, enabling children to construct scientific knowledge through authentic exploration while developing collaborative skills and environmental awareness.

International Perspectives and Best Practices

International research demonstrates the effectiveness of nature-based early childhood education across diverse cultural contexts. Scandinavian countries pioneered this approach through Norway's "friluftsliv" philosophy, which emphasizes outdoor living as fundamental to human well-being. Research in Norwegian kindergartens shows children in regular outdoor programs demonstrate improved physical health, enhanced social skills, increased environmental awareness, and superior academic performance compared to traditional indoor-focused programs (Sandseter & Lysklett, 2023).Finland's education system allocates 2-4 hours daily for outdoor activities regardless of weather, following the philosophy that "there is no bad weather, only bad clothing." Longitudinal studies reveal Finnish children in nature-rich programs show enhanced creativity, problem-solving skills, and environmental stewardship behaviors throughout their educational careers. The Forest School movement, originating in Denmark and spreading globally, emphasizes child-led learning and deep nature connection. Research consistently demonstrates positive outcomes including 67% improvement in confidence, enhanced social skills, stronger environmental awareness, and better academic performance in science and mathematics compared to indoor programs (Knight, 2021). Germany's "Waldkindergarten" model shows similar results, with children demonstrating superior motor development, enhanced creativity, reduced aggression, and improved school readiness.

Nature-Based Learning and Scientific Inquiry Development

Natural environments provide "high affordance" learning contexts that offer multiple opportunities for exploration, experimentation, and discovery (Gibson, 2019). Unlike controlled indoor environments, nature presents children with complex, dynamic systems that encourage adaptability, critical thinking, and acceptance of uncertainty—essential skills for scientific inquiry. The development of scientific inquiry skills in young children follows a predictable trajectory that aligns well with nature-based approaches. Research identifies key components including observational skills, classification abilities, hypothesis formation, experimentation strategies, and pattern recognition (Gelman & Brenneman, 2022).

Natural environments provide authentic contexts for developing these skills through direct observation of diverse materials, organisms, and phenomena that invite investigation. Recent neuro-educational research reveals that regular nature experiences during early childhood positively influence brain development, particularly areas related to attention, memory, and emotional regulation. These findings suggest that exposure to nature is not merely an educational method but a necessary factor for healthy brain development.

Environmental Education and Sustainability Awareness

Environmental attitudes and behaviors are largely formed during early childhood, making this a critical period for developing environmental stewardship mindsets (Evans et al., 2020). Nature-based science education provides authentic contexts for children to understand ecological relationships, resource conservation, and human impacts on natural systems. Studies demonstrate that children participating in nature-based programs develop stronger environmental attitudes, engage in more pro-environmental behaviors, and maintain these orientations throughout their lives (Cheng & Monroe, 2023).Research shows that direct nature experiences create emotional connections that translate into environmental consciousness and conservation behaviors. Children who regularly interact with natural environments develop stronger place attachment, ecological understanding, and motivation for environmental protection compared to peers with limited nature exposure.

Vietnamese Context and Challenges

The Vietnamese preschool education system has undergone significant expansion over recent decades, with improved infrastructure and enrollment rates. However, most programs remain focused on indoor classroom activities with limited access to natural environments, particularly in urban areas. This creates a gap between Vietnam's rich natural environment potential and actual utilization in early childhood education. Vietnam faces unique implementation challenges including rapid urbanization reducing urban green spaces, safety concerns, and traditional notions about "appropriate" learning environments. However, the country possesses significant advantages with rich biodiversity spanning from northern tropical forests to the Mekong Delta, providing diverse natural environments for educational purposes. Strong cultural traditions regarding human-nature relationships and indigenous knowledge create opportunities for integrating local knowledge into modern science education curricula.

Research Gaps and Opportunities

Despite extensive international research on nature-based science education, significant gaps remain, particularly in developing countries like Vietnam. Most current research is conducted in developed countries with different socioeconomic and environmental conditions. Few studies examine adaptation of nature-based models to Southeast Asian cultural, educational, and environmental characteristics. Additionally, limited research provides comprehensive frameworks addressing both theoretical foundations and practical implementation strategies. There is insufficient investigation of multiple stakeholder perspectives—children, teachers, parents, and administrators—regarding nature-based science education in Vietnamese contexts. This study addresses these gaps by developing a culturally-appropriate model for Vietnamese preschool education and examining implementation from multiple stakeholder perspectives.

Methodology

Research Design

This study employed a comprehensive mixed-methods research design to provide both quantitative evidence of program effectiveness and qualitative insights into implementation processes and stakeholder experiences. The research design was structured as a convergent parallel mixed-methods study, where quantitative and qualitative data were collected simultaneously and then integrated during analysis to provide a comprehensive understanding of nature-based science education implementation and outcomes (Creswell & Plano Clark, 2018). The quantitative component utilized a quasi-experimental design comparing children participating in nature-based science programs with matched control groups receiving traditional classroom-based science instruction. The qualitative component employed ethnographic methods including participant observation, in-depth interviews, and focus group discussions to understand the experiences and perspectives of children, teachers, parents, and administrators involved in nature-based programs.

Participants and Settings

The study was conducted across 15 kindergartens in three major regions of Vietnam: Northern region (Hanoi and surrounding provinces, n=5 schools), Central region (Da Nang and Hue, n=5 schools), and Southern region (Ho Chi Minh City and Can Tho, n=5 schools). This geographic distribution was designed to capture variations in climate, natural environments, urban-rural differences, and regional educational approaches. A total of 186 participants were included in the study: 98 children aged 4-6 years (intervention group: n=52, control group: n=46), 43 early childhood teachers and educational staff, 32 parents and family members, and 13 educational administrators and policy experts. Children were selected using stratified random sampling to ensure representation across age groups, gender, and socioeconomic backgrounds.

Data Collection

Multiple data collection methods were employed to capture different aspects of program implementation and

outcomes. Pre- and post-intervention assessments were conducted using validated instruments measuring scientific inquiry skills, environmental awareness, social-emotional development, and academic readiness. The Science Learning Assessment for Young Children was used to measure scientific inquiry skills including observation, classification, prediction, and experimentation abilities (Greenfield et al., 2019).Structured observations were conducted using the Classroom Assessment Scoring System framework to document teaching practices, child engagement, and learning environment quality during both nature-based and traditional instructional periods (Pianta et al., 2020). In-depth interviews were conducted with teachers (n=25), parents (n=20), and administrators (n=10) using semi-structured interview protocols designed to explore perspectives on nature-based education benefits, challenges, implementation strategies, and sustainability considerations.

Data Analysis

Quantitative data analysis employed both descriptive and inferential statistical methods using SPSS 28.0 software. Pre- and post-intervention scores were compared using paired-samples t-tests for within-group changes and independent samples t-tests for between-group comparisons. Effect sizes were calculated using Cohen's d to determine the practical significance of observed differences. Qualitative data analysis followed a systematic thematic analysis approach as outlined by Braun and Clarke (2022). Interview transcripts and observational notes were coded inductively to identify emerging themes and patterns. Initial coding was conducted independently by two researchers, with inter-rater reliability established through discussion and consensus.

Results

Quantitative Outcomes

Analysis of pre- and post-intervention assessments revealed statistically significant and practically meaningful improvements across multiple developmental domains for children participating in nature-based science education programs compared to control groups receiving traditional classroom-based instruction. The intervention group consisted of 52 children (mean age = 4.8 years, SD = 0.7; 27 boys, 25 girls) while the control group included 46 children (mean age = 4.9 years, SD = 0.6; 24 boys, 22 girls).

Table 1: Pre-Post Intervention Comparisons Between Nature-Based and Traditional Groups

Assessment Domain	Group	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Change	% Improvement	Effect Size (Cohen's d)	p-value
Scientific Inquiry Skills							
Overall Score	Nature-based	23.4 (4.2)	31.5 (3.8)	+8.1	34.7%	1.87***	<.001
	Traditional	24.1 (4.0)	26.3 (4.1)	+2.2	9.1%	0.54**	<.01
Observation Skills	Nature-based	5.8 (1.1)	8.3 (1.0)	+2.5	43.1%	2.35***	<.001
	Traditional	5.9 (1.2)	6.4 (1.3)	+0.5	8.5%	0.39*	<.05
Environmental Awareness							
Total Score	Nature-based	18.7 (3.9)	24.0 (3.2)	+5.3	28.3%	1.51***	<.001

Assessment Domain	Group	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Change	% Improvement	Effect Size (Cohen's d)	p-value
	Traditional	19.2 (3.7)	20.1 (3.9)	+0.9	4.7%	0.24	.17
Social-Emotional Development							
Self-regulation	Nature-based	42.3 (6.8)	53.5 (5.9)	+11.2	26.5%	1.77***	<.001
	Traditional	43.1 (6.5)	48.0 (6.7)	+4.9	11.4%	0.74**	<.01

*Note: *** $p < .001$, ** $p < .01$, * $p < .05$*

Scientific inquiry skills showed the most pronounced improvements, with the intervention group demonstrating a large effect size (d = 1.87) compared to the control group's small effect size (d = 0.54). Post-hoc analysis revealed that 89% of children in the intervention group showed clinically significant improvement compared to only 34% in the control group.

Qualitative Findings

Systematic thematic analysis of 58 interviews, 6 focus groups, and 120 hours of observational data revealed five primary themes characterizing stakeholder experiences with nature-based science education.

Enhanced Engagement and Motivation

Teachers universally reported dramatic increases in child engagement during nature-based learning activities. Quantitative observation data supported these reports, with children demonstrating 73% higher levels of sustained attention (≥5 minutes focused engagement) during outdoor compared to indoor science activities.

> *"The transformation is remarkable. Children who typically struggle to sit still for five minutes will spend an hour completely absorbed in investigating ant colonies or water flow patterns. They're not just participating - they're driving their own learning."* (Teacher, Northern Region, 8 years experience)

Children's focus group responses consistently emphasized the authentic, hands-on nature of outdoor learning:

> *"Inside, we just look at pictures of bugs. Outside, we can watch real bugs and see what they really do. That's more fun and I remember it better."* (Child, age 5.5, Central Region)

Holistic Learning and Development

Stakeholders consistently identified nature-based learning as supporting integrated development across multiple domains simultaneously. Observational data revealed that outdoor science activities naturally incorporated an average of 3.7 developmental domains per session compared to 1.4 domains in traditional classroom science instruction.

Teachers described seamless integration of academic and developmental goals:

> *"When children measure plant growth, they're using mathematical concepts like height, comparison, and*

data recording. When they describe their observations to peers, they're developing vocabulary and communication skills. When they work together to solve problems, they're building social competence. Everything connects naturally." (Teacher, Central Region, 12 years experience)

Authentic Learning Contexts

The real-world nature of outdoor learning environments provided meaningful contexts that children found personally relevant and applicable. Teachers emphasized improved knowledge transfer and application:

"Knowledge gained through direct experience seems to 'stick' differently. When children study the water cycle by observing actual rain, runoff, and evaporation in our outdoor classroom, they understand it at a deeper level than any diagram could achieve." (Teacher, Northern Region, 6 years experience)

Implementation Challenges and Solutions

While outcomes were overwhelmingly positive, stakeholders identified several implementation challenges and developed effective solutions. Weather emerged as the most frequently cited challenge (mentioned in 76% of interviews), but schools developed successful adaptation strategies:

"Initially, we cancelled outdoor sessions when weather wasn't perfect. Now we've learned that children can learn effectively in light rain, wind, or cold temperatures with appropriate clothing and modified activities. We only move indoors for severe weather." (Administrator, Central Region)

Discussion

Theoretical and Practical Implications

The substantial improvements in scientific inquiry skills (34.7% increase) and collaborative problem-solving abilities (31.2% enhancement) provide strong empirical support for constructivist and social constructivist learning theories. These findings validate Piaget's emphasis on direct environmental interaction and Vygotsky's collaborative learning framework, demonstrating how natural environments facilitate scientific thinking and social development more effectively than traditional classroom settings. Importantly, positive outcomes across diverse Vietnamese contexts—regardless of socioeconomic differences or urban-rural variations—suggest that nature-based approaches can reduce educational disparities while maintaining effectiveness. This finding supports broad scalability potential and aligns with Vietnam's educational equity goals.

Nature-Integrated Science Learning Environment Model for Vietnamese Preschoolers (NISLE-VN)

Based on empirical findings, we propose the *Nature-Integrated Science Learning Environment Model for Vietnamese Preschoolers (NISLE-VN*)—a framework specifically designed for tropical climate conditions and Vietnamese cultural characteristics. The model's effectiveness is demonstrated through 34.7% improvement in scientific inquiry skills and 28.3% increase in environmental awareness.

Four Core Pillars

*Pillar 1: Local Natural Experience (LNE***)** creates learning spaces including school gardens (50-100m²), natural playgrounds, and small animal areas. Activities are scheduled during optimal times (6:30-9:00 and 15:00-17:00) to maximize tropical climate advantages while integrating local flora and fauna familiar to children.

Pillar 2: Guided Scientific Inquiry (GSI) develops scientific capabilities through structured observation using magnifying glasses and measuring tools to investigate natural materials. Children conduct simple experiments and document findings in personal "science journals," encouraged to ask investigative questions and test predictions.

*Pillar 3: Community and Family Connection (CFC***)** builds school-family-community links by inviting parents with relevant expertise to share knowledge and collaborating with local conservation centers. Families create home "nature corners" and participate in "Little Science Fairs" where children present discoveries.

*Pillar 4: Safety and Holistic Development (SHD***)** ensures safety through the "3 No's" rule (no eating unknown plants, no touching strange animals, no wandering from teachers) while developing life skills through plant/animal care and enhancing social skills through collaborative outdoor activities.

Implementation and Evaluation

The model operates on a weekly cycle: Monday (New Discovery), Tuesday-Wednesday (Observation and Experimentation), Thursday (Expert Sharing), and Friday (Presentation and Reflection). Minimal infrastructure requirements include 50-100m² garden space, basic observation tools, and storage areas. Human resources need two trained teachers per class and community expert networks. Success criteria include 80% child participation rates, 20% improvement in observation skills, and 90% parent satisfaction. The model integrates Vietnamese cultural elements through local plant/animal names, traditional festival connections, and folk knowledge while maintaining economic feasibility for diverse school contexts. The NISLE-VN model provides educators with practical guidance for building nature-connected science learning environments that honor Vietnamese culture while developing scientifically literate, environmentally conscious citizens with essential 21st-century skills.

Conclusion and Recommendations

Summary of Key Findings and NISLE-VN Model Contributions

This comprehensive study provides compelling evidence for the effectiveness of nature-based science education in Vietnamese early childhood contexts. Children participating in nature-based programs demonstrated substantial improvements in scientific inquiry skills (34.7% improvement), environmental awareness (28.3% increase), and social-emotional development compared to traditional classroom-based instruction. These findings support constructivist and experiential learning theories while demonstrating practical applicability across diverse Vietnamese educational settings.

The primary contribution of this research is the development and validation of the *Nature-Integrated Science Learning Environment Model for Vietnamese Preschoolers (NISLE-VN)*—the first model specifically designed for tropical climate conditions, Vietnamese biodiversity, and local cultural characteristics. The NISLE-VN model comprises four core pillars: (1) Local Natural Experience (LNE), (2) Guided Scientific Inquiry (GSI), (3) Community and Family Connection (CFC), and (4) Safety and Holistic Development (SHD).

Empirical validation across 186 participants at 15 kindergartens in three regions demonstrates the model's effectiveness and scalability. Significantly, 87% of participating schools maintained programs six months post-research, indicating strong sustainability potential. The model's adaptability across regional variations, school types, and socioeconomic contexts suggests broad applicability within Vietnam's diverse educational landscape.

Policy Recommendations for Systematic Implementation

National Level Initiatives

The Ministry of Education and Training should implement the NISLE-VN model through a structured national pilot program targeting 50 representative kindergartens across three regions during 2024-2026. This initiative requires developing "Vietnamese Preschool Nature Learning Environment Standards" based on the model's four pillars, with specific indicators for infrastructure requirements, safety procedures, and assessment methods. A specialized "Nature Learning Environment Teacher Certification" program (60 hours theory + 40 hours practice) should be established to ensure quality implementation. This certification should focus on outdoor safety protocols, scientific observation techniques, and community engagement strategies aligned with NISLE-VN operational procedures.

Provincial and Institutional Implementation

Each province should establish 3-5 "NISLE-VN Model Kindergartens" as demonstration centers for experience sharing and peer training. A "Preschool Nature Education Development Fund" should provide targeted financial support (10-20 million VND per school annually for three years), prioritizing disadvantaged schools and ensuring equitable access to nature-based education opportunities. Kindergartens should implement the model gradually, beginning with the two most accessible pillars (Local Natural Experience and Safety Holistic Development) before expanding to include Guided Scientific Inquiry and Community Family Connection within two years. Each school should establish a "NISLE-VN Implementation Team" including administrators, trained teachers, parent representatives, and community experts to ensure comprehensive model operation.

Sustainability and Quality Assurance

Continuous evaluation mechanisms should include quarterly assessments using NISLE-VN model criteria, with results reported to management levels and activities adjusted based on stakeholder feedback. Success metrics include 80% child participation rates, 20% improvement in observation and questioning skills, and 90% parent satisfaction levels.

Broader Implications and Future Directions

The NISLE-VN model represents more than an academic contribution; it provides a practical framework for building science learning environments that align with Vietnamese conditions while meeting international educational standards. Successful national implementation will require coordinated efforts across all educational system levels and sustained commitment from multiple stakeholders. This research establishes a foundation for developing scientifically literate, environmentally conscious Vietnamese citizens with essential 21st-century skills. The model's emphasis on local knowledge integration, cultural relevance, and practical feasibility positions it as a scalable solution for enhancing early childhood science education across Vietnam. Future research should examine long-term developmental outcomes, cost-effectiveness analysis, and adaptation strategies for different geographic regions. Additionally, investigation of the model's applicability to other Southeast Asian contexts could expand its international impact.

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