Proceedings of Forum for University Scholars in Interdisciplinary Opportunities and Networking
Graduate School, Universitas Terbuka
https://conference.ut.ac.id/index.php/fusion

From Evidence to Practice: A Mixed-Method Study of Deep Learning and Nature-Based Learning for Fostering Creativity in Early Childhood

Ayu Riagandi[a*], Erie Siti Syarah[b]
[a*] Universitas Terbuka, Banten, Indonesia, 501352822@ecampus.ut.ac.id
[b] Universitas Terbuka, Banten, Indonesia, syaraherie@ecampus.ut.ac.id

*Correspondence: 501352822@ecampus.ut.ac.id

Abstract
Creativity is a foundational competency in early childhood education, yet teacher-centered routines and assessment-driven practices often curtail children's authentic exploration. This paper examines how deep-learning strategies can be integrated with nature-based learning to foster creativity in developmentally appropriate ways. We adopted a mixed-method design: a Systematic Literature Review (2014–2024) that identified 41 eligible studies, and a needs analysis with 45 stakeholders (teachers, school leaders, curriculum developers) using surveys and follow-up interviews. The review shows that nature-based pedagogies reliably support divergent thinking, problem-solving, and socio-emotional well-being through multisensory, open-ended activities, whereas current deep-learning applications in early childhood are concentrated on personalization and assessment rather than creativity. Field data indicate strong practitioner openness to hybrid approaches—conditional on teacher mediation, minimal screen time, privacy-by-design, and feasibility under infrastructure constraints. Synthesizing both strands, we propose a nature-first, tech-light framework: outdoor provocations as the creative engine; AI used for low-intrusion documentation, pattern-spotting, and reflective prompts; offline-first delivery; and assessment that privileges portfolios and observational rubrics over narrow screen-based proxies. The study advances the field by translating scattered evidence into implementable design requirements and by offering a context-sensitive pathway for scaling creativity-oriented hybrid pedagogy in early childhood settings.

Keywords:
early childhood creativity, deep learning, nature-based learning, mixed-method, needs analysis

1. Introduction

Creativity is increasingly acknowledged as a cornerstone of early childhood education (ECE), equipping children with the capacity for divergent thinking, flexible problem-solving, and adaptability in a rapidly evolving world (Craft, 2019; Robinson, 2020). Early childhood constitutes a critical developmental window in which the foundations of creative potential are laid, shaping children's innovation capacity and life-long learning dispositions (Torrance, 2018). Despite this recognition, prevailing pedagogical practices in many educational settings remain heavily oriented toward structured outcomes, rote instruction, and standardized assessments, thereby limiting authentic exploration, imagination, and self-directed learning opportunities (Jeffrey & Craft, 2019; Parette, Quesenberry, & Blum, 2010).

Recent scholarship emphasizes the value of pedagogies that support unstructured exploration, multisensory engagement, and learner autonomy, particularly through nature-based learning approaches (Wells & Lekies, 2021; Bento & Dias, 2017). Nature-based education offers rich, open-ended experiences in natural environments that foster ecological awareness, curiosity, and creative expression (Kuo, Barnes, & Jordan, 2019; Gull, Leven, & Sager, 2019). These experiences are especially relevant

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

for promoting socio-emotional well-being and cognitive flexibility, both of which underpin creative thinking. Simultaneously, rapid advances in deep learning—a branch of artificial intelligence (AI) that enables adaptive and personalized digital learning environments—have expanded the potential to support early learning in areas such as language acquisition, cognitive assessment, and adaptive feedback (Chen, Chen, & Lin, 2020; Holmes, Bialik, & Fadel, 2019; Luckin, 2018). However, existing studies on deep learning in early childhood education have predominantly focused on academic skill acquisition, learning analytics, and assessment optimization, with little empirical or conceptual attention given to how deep-learning–supported digital environments might be intentionally designed to foster creativity, particularly when integrated with experiential, nature-based pedagogies. To date, no prior research has explicitly examined how deep learning technologies can be systematically integrated with nature-based learning to intentionally support creative development in early childhood education, leaving such integration conceptually and pedagogically underdefined (Solichah & Shofiah, 2023; OECD, 2021).

This disconnect reveals a critical research gap: while nature-based approaches have been shown to stimulate creativity and socio-emotional growth, they are seldom integrated with advanced technological tools to build adaptive and sustainable models. Conversely, deep learning systems have been widely adopted for personalized instruction but rarely designed to enhance creativity in developmentally appropriate ways for young children (Chen et al., 2020; Zawacki-Richter, Marín, Bond, & Gouverneur, 2019). Meanwhile, conventional teacher-centered practices continue to dominate in many early education contexts, constraining children's opportunities to engage with both natural and digital affordances in creative, exploratory ways (Wilson, 2018).

Addressing this gap is essential to modernize early childhood pedagogy in line with 21st-century learning demands and sustainable development goals (SDGs 4 & 15). This study proposes an integrative framework that bridges the experiential richness of nature-based learning with the adaptive, personalized potential of deep learning technologies. Through this hybrid approach, educators can create environments that nurture creativity, resilience, and ecological awareness while responsibly leveraging digital innovation.

Building on the identified research gap, this study is driven by a central inquiry into how deep learning strategies can be integrated with nature-based learning to effectively foster creativity in early childhood education. To address this overarching question, the research first examines the ways in which nature-based learning contributes to the development of creativity by encouraging exploration, sensory engagement, and imaginative play. It then analyzes how deep learning technologies have been applied in early childhood contexts and the extent to which such applications support creative growth among young children. In parallel, the study investigates the needs and expectations of early childhood educators, administrators, and curriculum stakeholders regarding the potential integration of deep learning with nature-based pedagogies. Insights from these strands inform the development of an integrative conceptual framework that bridges evidence-based knowledge with field-driven demands, offering a model for designing learning environments that are adaptive, developmentally appropriate, and creativity-oriented. Through these efforts, the study advances theoretical understanding of hybrid pedagogy while providing actionable guidance for curriculum designers, teachers, and policymakers committed to shaping innovative, context-sensitive, and sustainable early learning experiences.

Guided by the gaps identified in the literature and the field signals from practitioners, this study asks how deep-learning strategies can be meaningfully combined with nature-based learning to cultivate early childhood creativity. Specifically, we explore four interrelated questions: (1) in what ways nature-based learning fosters creative thinking and expression among young children; (2) how— and to what extent—current deep-learning/AI applications have been used to support creativity in early childhood contexts; (3) what needs and expectations practitioners and curriculum stakeholders articulate regarding the integration of deep learning with nature-based pedagogy; and (4) what design requirements can be derived from the synthesis of research evidence and practice-based insights to shape a developmentally appropriate, context-sensitive hybrid framework.

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

2. Method

This study employed a mixed-method research design that strategically combined a *Systematic Literature Review (SLR)* and a *needs analysis survey* to generate a comprehensive understanding of the interplay between deep learning and nature-based learning in fostering creativity in early childhood education. The integration of these approaches provided both a rigorous synthesis of theoretical and empirical knowledge from prior research and practical insights drawn from field-based stakeholders such as educators, administrators, and curriculum developers. Such a design is consistent with the exploratory sequential mixed-methods approach, which allows the evidence obtained from the literature review to inform the development of instruments and focus areas for the subsequent field inquiry (Creswell & Creswell, 2018).

2.1. Research Design

The study followed an exploratory sequential mixed-methods design, where the SLR was conducted as the first phase to synthesize evidence from international publications, followed by a needs analysis in the second phase. Findings from both phases were triangulated to develop an integrative framework for combining deep learning and nature-based learning in fostering creativity among young children. The SLR ensured methodological transparency and replicability, while the needs analysis captured context-specific perspectives from practitioners.

Table 1
Design and Phases of the Study

Phase	Purpose	Key Activities	Data Sources / Participants	Analysis Techniques
Phase 1: Systematic Literature Review (SLR)	To synthesize global theoretical and empirical evidence on early childhood creativity, nature-based learning, and deep learning.	- Formulating research questions and inclusion/exclusion criteria. - Conducting comprehensive searches in Scopus, Web of Science, SpringerLink, ScienceDirect, and ERIC (2014–2024). - Cleaning data and removing duplicates (716 → 241 studies). - Screening abstracts and assessing full-text quality (final inclusion: 41 studies).	International peer-reviewed publications relevant to creativity, deep learning, and nature-based learning.	- Bibliometric mapping (VOSviewer). - Thematic coding to identify patterns and research gaps.
Phase 2: Needs Analysis (Survey & Interviews)	To explore practitioners' and stakeholders' needs to ensure the proposed model is contextually relevant.	- Designing semi-structured questionnaires informed by the SLR findings. - Distributing surveys to early childhood educators, administrators, and curriculum developers (n = 45). - Conducting in-depth interviews with a subsample to investigate teacher readiness, infrastructure, and technology adoption.	Early childhood teachers, school leaders, and curriculum developers from public and private institutions in Indonesia.	- Descriptive statistics (frequency, percentage, mean). - Inductive thematic analysis (Braun & Clarke, 2006).
Integration & Triangulation	To combine theoretical evidence and field-based insights in developing a hybrid	- Comparing SLR findings with field data. - Validating the relevance of the conceptual framework with practitioners' needs.		

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

Phase	Purpose	Key Activities	Data Sources / Participants	Analysis Techniques
	learning framework for fostering creativity.	- Developing implementation recommendations.		

2.2. Sources and Search Strategy

To ensure transparency and reproducibility of the systematic literature review (SLR), it is essential to clearly report the sources and search strategies employed. Table 2 provides a structured overview of the databases consulted, the Boolean search strings used, and the publication time span applied. This level of detail helps readers understand how the study identified, screened, and selected relevant evidence on early childhood creativity, nature-based learning, and deep learning.

Table 2.
Data Sources and Search Strategy for the SLR

Element	Description
Databases Searched	Scopus, Web of Science, SpringerLink, ScienceDirect, ERIC, and Google Scholar
Search Strings / Keywords	• "early childhood creativity" • "deep learning in early childhood education" • "nature-based learning" OR "outdoor learning" • "AI and creativity in young children" • "environment-based education AND creativity"
Search Techniques	Combination of Boolean operators (AND, OR) to refine and expand keyword coverage; filtering by field relevance (education, early childhood development, learning technologies).
Time Span of Publications	2014–2024 (to capture both foundational and recent research developments).
Language	English only (to ensure consistency and accessibility of research data).
Inclusion Rationale	Studies were included if they focused on early childhood education, creativity, deep learning, and/or nature-based learning with clear methodological contributions.

2.3. Participants

This study engaged two distinct participant groups aligned with its sequential mixed-methods design. The first group comprised the SLR corpus, consisting of scholarly publications systematically identified and retrieved from major academic databases. After a rigorous screening process guided by predetermined inclusion and exclusion criteria—such as relevance to early childhood creativity, deep learning, and nature-based education; methodological clarity; and publication within the 2014–2024 time frame—a total of 41 peer-reviewed articles were selected for in-depth analysis. These studies formed the theoretical foundation of the research, offering insights into global trends, conceptual frameworks, and documented practices that inform the proposed hybrid pedagogical model.

The second group involved respondents for the needs analysis, recruited using a purposive sampling strategy to ensure representation of key stakeholders in early childhood education. A total of 45 participants took part, including classroom educators, school administrators, and curriculum developers from a diverse range of public and private early learning institutions in Indonesia. This group contributed practical and context-specific perspectives by completing a semi-structured survey and participating in follow-up interviews. Their input provided nuanced understanding of teacher readiness, curriculum priorities, and potential challenges in integrating technology with nature-based approaches, thereby ensuring that the proposed framework was grounded not only in international evidence but also in the realities of local practice.

2.4. Inclusion and Exclusion Criteria

Table 3

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

Inclusion and Exclusion Criteria

Aspect	Inclusion Criteria	Exclusion Criteria
Publication type	Peer-reviewed journal articles, books, and conference proceedings	Editorial notes, commentaries, or non-empirical works
Timespan	Studies published between 2014–2024	Publications outside the time frame
Language	Written in English	Non-English articles
Scope	Focused on early childhood education, creativity, deep learning, and/or nature-based learning	Studies outside education (e.g., engineering, medicine)
Accessibility	Full-text accessible	Full-text not available
Originality	Unique and non-duplicated	Duplicated publications
Methodology	Clear and explicit research methods	No methodological explanation
Quality	Empirical or theoretical contribution relevant to creativity in early childhood	Studies with no significant contribution

2.5. Data Collection Process

The research was conducted in two sequential phases to ensure both theoretical rigor and contextual relevance. In Phase 1 — Systematic Literature Review (SLR), a structured search and selection process was performed following the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020* guidelines (Page et al., 2021). During the identification stage, an extensive search across multiple reputable databases—including *Scopus, Web of Science, SpringerLink, ScienceDirect, ERIC,* and *Google Scholar*—yielded an initial pool of 716 records. In the screening stage, duplicate entries were carefully removed, reducing the dataset to 241 unique studies. The eligibility stage involved a critical appraisal of abstracts and full texts based on predefined inclusion and exclusion criteria, focusing on relevance to early childhood creativity, deep learning, and nature-based education, as well as methodological transparency and empirical contribution. This process narrowed the selection to 127 eligible documents. Finally, the inclusion stage yielded a refined set of 41 studies deemed methodologically robust and directly aligned with the study's objectives. These selected works were then analyzed to map publication trends, synthesize conceptual frameworks, and identify knowledge gaps to inform the subsequent field investigation.

In Phase 2 — Needs Analysis, the study shifted from theoretical synthesis to field-based validation by gathering insights from practitioners and key stakeholders in early childhood education. Data were collected through semi-structured questionnaires that explored participants' perceptions of creativity, their current practices in integrating nature-based and technology-supported learning, and their expectations for the development of hybrid pedagogical models. To complement and deepen these findings, follow-up interviews were conducted with a subset of respondents, focusing on issues such as teacher readiness, infrastructural opportunities and limitations, ethical considerations of artificial intelligence (AI) in early childhood, and the cultural appropriateness of combining digital tools with ecological experiences. Quantitative survey responses were analyzed using descriptive statistics, while qualitative interview data were examined through inductive thematic analysis following the six-step approach proposed by Braun and Clarke (2006). This two-phase design enabled a robust triangulation of global theoretical insights and local contextual needs, strengthening the validity and applicability of the proposed integrative framework for fostering creativity in early childhood education.

2.6. Data Analysis

The data analysis process was organized to reflect the sequential mixed-methods design of the study and to ensure both depth and methodological rigor. For the Systematic Literature Review (SLR), a bibliometric analysis was conducted using *VOSviewer* to visualize and map research trends, including the co-occurrence of keywords, authorship networks, and thematic clusters associated with early childhood creativity, nature-based pedagogy, and the application of deep learning technologies in educational contexts. This quantitative mapping provided an overview of the intellectual structure and evolution of the field, enabling the identification of influential studies, knowledge gaps, and emerging

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

directions. In parallel, thematic coding was applied to the full-text corpus to qualitatively synthesize evidence and generate a deeper conceptual understanding of how these key constructs have been framed and operationalized across the literature (Miles, Huberman, & Saldaña, 2014).

For the needs analysis data, quantitative responses collected from the semi-structured questionnaires were examined using descriptive statistics, including frequency distributions, percentages, and measures of central tendency. This statistical profiling offered an empirical snapshot of teachers' and curriculum developers' perceptions, existing practices, and readiness to integrate nature-based and technology-supported learning approaches. Complementing this, qualitative interview data were analyzed inductively through the six-phase thematic analysis framework proposed by Braun and Clarke (2006). This process included familiarization with the data, generating initial codes, developing and refining candidate themes, and producing a coherent interpretive account of practitioners' insights, including challenges and opportunities related to infrastructure, teacher competencies, ethical concerns in AI use with young children, and cultural appropriateness of hybrid learning models.

Finally, the two strands of evidence were brought together through methodological triangulation (Miles et al., 2014). The integration involved systematically comparing theoretical patterns from the SLR with practical findings from the field to validate and refine emerging conclusions. This process enhanced both the credibility and transferability of the study's results by ensuring that the proposed hybrid pedagogical framework was not only grounded in robust global scholarship but also adaptable to local educational contexts and practitioner needs.

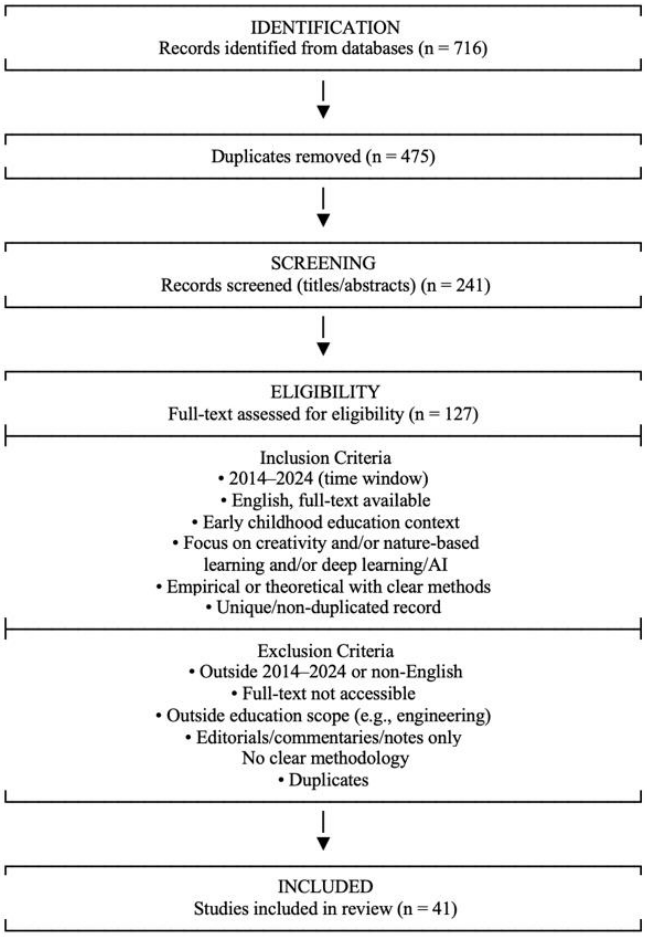
3. Results and Discussion

3.1 Results

Phase one, the Systematic Literature Review (SLR) conducted over the period 2014–2024 identified a total of 41 studies that met the inclusion criteria after a rigorous screening process based on PRISMA 2020 guidelines (Page et al., 2021). The bibliometric analysis revealed three major findings.

Figure 1
PRISMA 2020 flow diagram (vertical)

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author



To enhance transparency and reproducibility, the *Systematic Literature Review* was reported in accordance with the PRISMA 2020 guideline, which structures the selection process into four stages—identification, screening, eligibility, and inclusion. The PRISMA flowchart (Figure 1) visualizes each decision point and sample size: records identified through database searching, duplicates removed prior to screening, titles and abstracts screened, full texts assessed for eligibility against predefined inclusion and exclusion criteria (publication window, language, scope in early childhood education, relevance to creativity, nature-based learning, and deep learning, as well as methodological clarity), and the final number of studies included in the synthesis. At this eligibility stage, the methodological quality of the full-text articles was critically appraised using established tools, namely the Critical Appraisal Skills Programme (CASP) checklist for qualitative studies and the Joanna Briggs Institute (JBI) critical appraisal tools for quantitative and mixed-methods studies, to ensure the rigor, transparency, and relevance of the evidence included in the review. This schematic documents the progressive narrowing of the corpus and provides a clear audit trail from the initial search to the studies retained for analysis.

Table 4 synthesizes the core results of the 2014–2024 SLR into a comparative matrix that maps the bibliometric landscape and three dominant thematic clusters, revealing three overarching patterns: (1) a methodologically mature and well-established body of evidence supporting the role of nature-based and outdoor learning in fostering early childhood creativity; (2) a rapidly expanding yet predominantly academically oriented literature on deep learning and AI in early childhood education, in which creativity is addressed only implicitly; and (3) a notable scarcity of empirical and conceptual studies that intentionally integrate nature-based pedagogy with deep-learning–supported practices to promote creativity**.** For each item/cluster, the table reports (i) core constructs and focal concerns, (ii) typical outcomes reported across studies, (iii) common samples/contexts represented in the corpus, and (iv) the measures of creativity most frequently used, alongside (v) representative references, (vi) evidence density as an indicator of maturity (High/Moderate/Low), (vii) key gaps and limitations, and (viii)

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

resulting design implications for a creativity-oriented hybrid framework. The "Representative References" column is illustrative rather than exhaustive; full citations are provided in the reference list. Read left-to-right to trace how each evidence strand translates into concrete design guidance for integrating nature-based pedagogy with deep-learning–supported practices in early childhood settings.

Table 4
Matrix of SLR Findings (2014–2024)

Item / Cluster	Core Constructs & Focus	Representative References	Evidence Density (2014–2024)	Design Implications for the Hybrid Framework
Bibliometric Trend	Growth of publications on ECE creativity; surge of studies integrating nature-based + technology post-2018; outlets largely Scopus/WoS	(e.g., Johnstone et al., 2022)	High growth after 2018	Justify originality; position studies as bridging global evidence with local context; target scalable, context-sensitive models
Cluster 1: Nature-based / Outdoor Learning	Unstructured exploration, multisensory engagement, ecological awareness as drivers of creativity	Wells & Lekies (2006); Bento & Dias (2017); Johnstone et al. (2022); Setyaningsih et al. (2024)	High (well-established)	Embed outdoor provocations (garden, loose parts) with low-intrusion documentation (photo/audio) to capture creative products/process; align with developmentally appropriate practice
Cluster 2: Deep Learning / AI in ECE	Personalization, language development, formative assessment; emerging digital creativity tools	Zawacki-Richter et al. (2019); Chen et al. (2020); Holmes et al. (2019); Luckin (2018); Solichah & Shofiah (2023)	Moderate and rising	Use DL for creative analytics (e.g., image/audio tagging of artifacts), not as replacement for play; set guardrails (privacy, minimal screen-time); teacher-in-the-loop dashboards
Cluster 3: Integrative / Hybrid Models	Coupling ecological exploration with digital augmentation (sensing, documentation, adaptive prompts)	Bærentsen & Trettvik (2021) and scattered pilots	Low / Emerging	Co-design hybrid units with teachers; run iterative pilots (design-based research), then quasi-experimental/RCT where feasible; include cultural & environmental alignment

Phase two. The survey of 45 early childhood education stakeholders (teachers, school leaders, and curriculum developers) was dominated by teachers (60%), followed by administrators (25%) and curriculum developers (15%). Substantively, 80% of respondents affirmed that direct engagement with nature is a primary driver of children's creativity—most often linked to curiosity, problem solving, and emotional well-being. In parallel, over 70% expressed openness to digital/AI tools to enrich creative learning, conditional on developmentally appropriate use and teacher-mediated orchestration rather than device-centric activities. At the same time, practical constraints surfaced: infrastructure gaps (65%) and the need for teacher training on integrating technology with outdoor learning (60%). These quantitative patterns were echoed and elaborated in interviews, which called for context-specific hybrid models that are culturally responsive, low-intrusion, and supported by hands-on professional development and ongoing technical assistance.

Figure 2 summarizes the Phase-2 survey results by pairing respondent demographics with headline perceptions. The sample (n = 45) was dominated by teachers, followed by school administrators and curriculum developers, providing a practitioner-centric view of implementation realities. The right panel aggregates the principal findings: strong endorsement of direct nature engagement as a driver of children's creativity, broad openness to developmentally appropriate and teacher-mediated uses of digital/AI tools, and two salient barriers—infrastructure gaps and the need for targeted teacher training

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

to integrate technology with outdoor learning. Percentages are descriptive (purposive sample) and are intended to inform the design requirements outlined in the subsequent section.

Figure 2

Survey infographic (demographics + key findings)

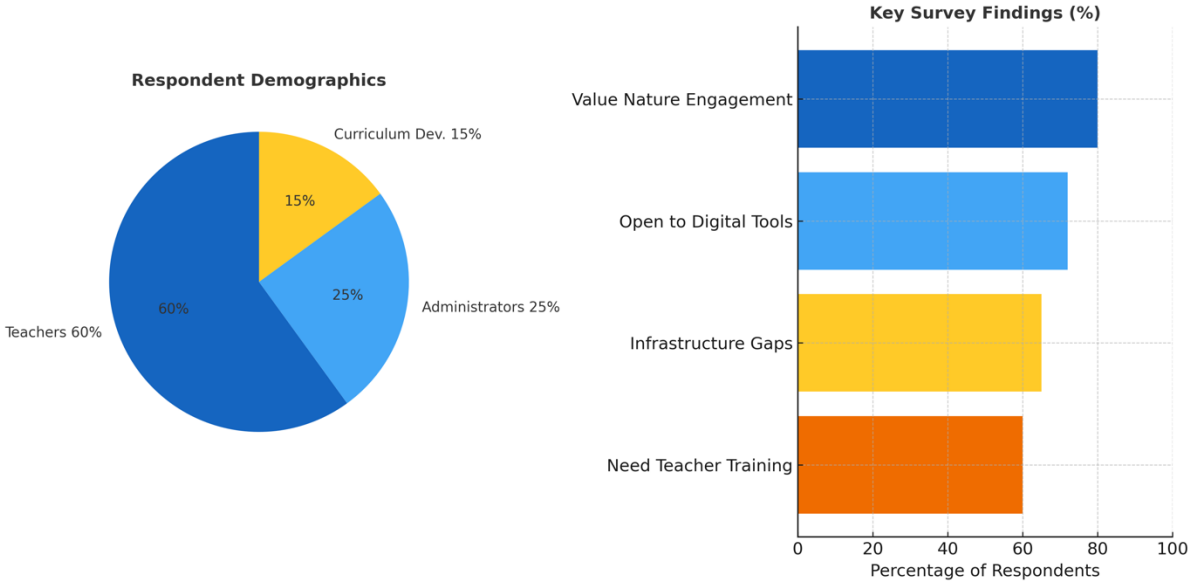


Table 4 consolidates the Phase-2 survey outputs into a compact summary of who responded and what they reported. The upper panel profiles the purposive sample (n = 45)—teachers, school administrators, and curriculum developers—while the lower panels aggregate headline perceptions and implementation barriers. Read left-to-right to see that respondents strongly value direct nature engagement for fostering children's creativity, express broad openness to developmentally appropriate, teacher-mediated digital/AI tools, and simultaneously flag two practical constraints: infrastructure gaps and the need for targeted teacher training to integrate technology with outdoor learning. Percentages are descriptive indicators intended to inform the design requirements discussed in the subsequent subsection.

In summary, the Phase-2 survey highlights three core findings. First, practitioners strongly endorse direct engagement with natural environments as a primary driver of early childhood creativity. Second, there is broad openness to the use of digital and AI tools, provided that such tools are developmentally appropriate and mediated by teachers rather than device-centered. Third, implementation is constrained by structural and capacity-related barriers, particularly infrastructure limitations and insufficient teacher training. Together, these findings underscore the need for a hybrid creativity framework that is low-intrusion, context-sensitive, and supported by sustained professional development.

Table 4

Demographics and Key Findings

Component	Indicator	Value
Respondent Demographics (n = 45)	Teachers	60%
	Administrators	25%
	Curriculum Developers	15%
Perceptions & Attitudes	Value direct nature engagement for creativity	80%
	Openness to digital/AI tools (developmentally appropriate, teacher-mediated)	>70%
Implementation Barriers	Infrastructure gaps (devices/connectivity)	65%
	Need for teacher training (tech–outdoor integration)	60%

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

Overall, the findings highlight both opportunities and challenges in combining deep learning and nature-based approaches to foster creativity in early childhood education. Importantly, the review reveals that empirical studies integrating AI-supported deep learning with nature-based pedagogy are still scarce, thereby positioning this study to fill a critical research gap in advancing hybrid models for early childhood creativity.

Triangulating findings from both phases shows strong conceptual alignment and practical urgency for a hybrid creativity-focused learning model. The global evidence base confirms the potential of nature-based pedagogy for fostering creativity but reveals minimal integration with adaptive digital tools. Meanwhile, local stakeholders are highly interested in hybrid approaches but require clear guidance, culturally responsive frameworks, and adequate training to overcome barriers to implementation. This synthesis directly informs the conceptual framework proposed by the study, ensuring that it is both evidence-informed and field-driven.

3.2 Discussion

This study advances a nature-first, tech-light account of how creativity can be cultivated in early childhood, grounded in constructivist and socio-cultural theories that emphasize active exploration, environmental affordances, and socially mediated meaning-making (Piaget, 1952; Vygotsky, 1978; Malaguzzi, 1998)**.** In brief, the evidence indicates that (a) nature-based experiences provide the richest proximal conditions for divergent thinking, flexible problem solving, and emotionally safe exploration—findings that align with prior research on outdoor and nature-based learning as catalysts for creativity and self-regulation (Bento & Dias, 2017; Kuo et al., 2019; Johnstone et al., 2022); (b) deep-learning/AI tools add value when they augment those experiences—documenting artifacts, surfacing patterns, or prompting reflection—rather than replacing hands-on inquiry, consistent with AI-in-education studies that caution against technology-driven instruction in early childhood (Luckin, 2018; Zawacki-Richter et al., 2019; Chen et al., 2020); and (c) practitioners endorse hybrid models provided they are developmentally appropriate, teacher-mediated, ethically safe, and feasible in everyday classrooms, echoing earlier calls for teacher-in-the-loop and low-intrusion technology integration in ECE settings (Holmes et al., 2019; OECD, 2021). Together, these convergent findings specify not only where technology belongs in early childhood creativity pedagogy, but also where it does not, reinforcing longstanding theoretical positions that place play, environment, and human mediation at the center of early learning.

The work asked how deep-learning strategies can be integrated with nature-based learning to foster creativity, what the field has already attempted, what stakeholders need, and what design requirements follow. Taken together, the SLR and the needs analysis support a hybrid framework that keeps outdoor, open-ended activity at the center and positions AI as a support layer for documentation, low-intrusion analytics, and teacher-facing prompts. This directly addresses the aims set in the Introduction by translating broad aspirations (“integrate AI and nature-based learning for creativity”) into concrete roles, safeguards, and delivery conditions.

Nature-rich contexts appear especially potent for creativity because they maximize multisensory affordances, novelty, and productive ambiguity—conditions that elicit ideation and flexible strategy use. They also foster socio-emotional resources (joint attention, risk negotiation, peer collaboration) that sustain creative engagement over time (Bento & Dias, 2017; Kuo et al., 2019; Johnstone et al., 2022). Within such ecologies, deep learning is most defensible when it operates in the background—e.g., organizing children’s drawings or audio clips into recognizable patterns, curating growth-visible portfolios, or suggesting next prompts to teachers—without fragmenting play or inflating screen time. The practitioner data clarify that developmental appropriateness, teacher mediation, and privacy-by-design are not peripheral ethics box-checks; they are mechanistic preconditions for preserving autonomy, immersion, and emotion—the very substrates of creative learning.

The pattern aligns with converging evidence that contact with nature promotes learning and self-regulation and with AI-in-education reviews showing that early deployments cluster around personalization and assessment rather than creativity (Chen et al., 2020; Kuo et al., 2019; Zawacki-Richter et al., 2019). Where this study extends the literature is in design granularity for early childhood: teacher-in-the-loop adaptivity, low-intrusion capture of creative processes, offline-first/low-bandwidth

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

operation, and authentic assessment (portfolios, observation rubrics, process-sensitive indicators) suited to 3–6-year-olds. A second contribution is context sensitivity: stakeholders emphasize cultural fit, infrastructure variability, workload realities, and data safeguards—factors that remain under-specified in many technology-forward accounts (Holmes et al., 2019; Luckin, 2018).

Taken together, the triangulated evidence specifies a coherent path for implementation. At its core is nature-first orchestration: outdoor provocations—gardening, loose parts, field walks—remain the primary engine of creative inquiry, while technology plays a secondary role that heightens reflection and visibility of learning rather than directing children's activity (Bento & Dias, 2017; Johnstone et al., 2022; Kuo et al., 2019). Within this ecology, teacher-in-the-loop adaptivity is essential: AI may generate suggestions or surface patterns in children's artifacts, but teachers curate, contextualize, and ultimately decide; any analytics interface should therefore foreground succinct patterns and exemplars without prescribing pace or content (Chen et al., 2020; Holmes et al., 2019; Luckin, 2018).

These design choices must sit inside an ethical architecture that treats privacy and developmental fit as first-order constraints—privacy-by-design (de-identification and, where feasible, local/on-device processing), transparent consent, and minimal, purposeful screen time that never displaces embodied exploration (OECD, 2021; Zawacki-Richter et al., 2019). Delivery should also be resilient: offline-first and low-bandwidth options ensure that outdoor sessions are not contingent on connectivity (Holmes et al., 2019; OECD, 2021). Finally, evaluation needs to honor process. Rather than relying on narrow screen-based proxies, assessment should pair child-friendly indicators of fluency and flexibility with portfolios and observational rubrics that capture the evolution of ideas, collaboration, and problem-solving *in situ* (Bento & Dias, 2017; Johnstone et al., 2022).

Limitations

Phase-2 survey percentages are descriptive and derived from a purposive sample; generalizability is limited. Creativity measures across studies remain heterogeneous, and integrative trials are typically small and brief. Future work should: (a) co-design hybrid units with teachers and iterate via design-based research; (b) scale to quasi-experimental or randomized trials; (c) adopt a common, developmentally valid assessment set that pairs portfolios/process rubrics with light, comparable indicators; and (d) examine equity and cultural variation, ensuring models adapt to urban/rural settings and resource constraints.

The value proposition of combining deep learning with nature-based pedagogy is conditional: it succeeds when AI functions as a quiet amplifier of children's outdoor inquiry and teachers' professional judgment. Under those conditions, the hybrid model is not a compromise between "screens" and "sticks and stones," but a coherent pedagogy that preserves the generative messiness of nature while making creative growth visible, discussable, and refinable.

4. Conclusion

Drawing directly on the findings of the Systematic Literature Review and the Phase-2 stakeholder survey, this study shows that early-childhood creativity is most effectively fostered through a nature-first, tech-light model, in which outdoor, open-ended activities function as the primary learning engine, while deep-learning/AI tools operate as teacher-mediated supports for documentation, pattern recognition, and reflective prompting. The SLR confirms that the evidence base for nature-based learning and creativity is methodologically strong and well established, whereas existing AI applications in early childhood education remain largely assessment-oriented and only indirectly related to creativity; this pattern is reinforced by the survey results, which indicate strong practitioner endorsement of nature-rich learning, conditional openness to developmentally appropriate AI use, and persistent constraints related to infrastructure and teacher capacity**.** By synthesizing these findings, the study advances the literature by translating empirical and practice-based insights into implementable design requirements, including teacher-in-the-loop adaptivity, privacy-by-design with minimal and purposeful screen time, offline-first delivery, and process-oriented assessment approaches such as portfolios and observation rubrics. As discussed, this positioning is theoretically and

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

empirically justified because multisensory and socially rich outdoor contexts provide the proximal conditions for divergent thinking and flexible problem solving, while AI adds value only when it functions as a low-intrusion amplifier that makes creative processes visible without displacing embodied exploration. Practically, the proposed framework informs curriculum unit design, formative teacher decision-making, program evaluation, and targeted professional development. Future research should extend this work from design-based pilots to quasi-experimental or randomized studies using shared, developmentally valid creativity measures, complemented by longitudinal and implementation-focused inquiries addressing equity, cultural fit, data protection, and teacher workload to support responsible scaling across diverse early-learning contexts..

5. References

Bærentsen, K. B., & Trettvik, J. (2021). Designing Hybrid Learning Environments: Combining Digital Tools and Nature-Based Experiences. In *Proceedings of the 15th International Conference on Interaction Design and Children* (pp. 55–65). ACM.

Bento, G., & Dias, G. (2017). The importance of outdoor play for young children's healthy development. *Porto Biomedical Journal, 2*(5), 157–160. https://doi.org/10.1016/j.pbj.2017.03.003

Bento, G., & Dias, G. (2017). The importance of outdoor play for young children's healthy development. *Porto Biomedical Journal, 2*(5), 157–160. https://doi.org/10.1016/j.pbj.2017.03.003

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063o

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access, 8*, 75264–75278. https://doi.org/10.1109/ACCESS.2020.2988510

Craft, A. (2019). *Creativity and education futures: Learning in a digital age* (2nd ed.). Trentham Books.Gull, C., Leven, T., & Sager, S. (2019). Outdoor play and nature-based learning in early childhood education. *Journal of Adventure Education and Outdoor Learning, 19*(3), 227–241. https://doi.org/10.1080/14729679.2018.1507831

Edwards, C., Gandini, L., & Forman, G. (2012). *The Hundred Languages of Children: The Reggio Emilia Experience in Transformation* (3rd ed.). Praeger.

Gardner, H. (2009). *Multiple Intelligences: New Horizons*. Basic Books.

Gull, C., Leven, T., & Sager, S. (2019). Outdoor play and nature-based learning in early childhood education. *Journal of Adventure Education and Outdoor Learning, 19*(3), 227–241. https://doi.org/10.1080/14729679.2018.1507831

Halimah, L. (2020). Teachers' Perspectives on Blended Learning in Early Childhood Education: Challenges and Opportunities. In *Proceedings of the 5th International Conference on Education and Technology (ICET)*. Atlantis Press.

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Jeffrey, B., & Craft, A. (2019). Creative teaching and teaching for creativity: Distinctions and relationships. *Educational Studies, 45*(1), 77–88.

Johnstone, A., Martin, A., Cordovil, R., Fjørtoft, I., Iivonen, S., Jidovtseff, B., … Wells, V. (2022). Nature-Based Early Childhood Education and Children's Social, Emotional and Cognitive Development: A Mixed-Methods Systematic Review. *International Journal of Environmental Research and Public Health, 19*(10), 5967. https://doi.org/10.3390/ijerph19105967

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author

Kuo, M., Barnes, M., & Jordan, C. (2019). Do experiences with nature promote learning? Converging evidence of a cause-and-effect relationship. *Frontiers in Psychology, 10*, 305. https://doi.org/10.3389/fpsyg.2019.00305

Luckin, R. (2018). Machine learning and human intelligence: The future of education for the 21st century. UCL IOE Press.

Malaguzzi, L. (1998). *History, ideas, and basic philosophy: An interview with Lella Gandini*. In C. Edwards, L. Gandini, & G. Forman (Eds.), *The hundred languages of children: The Reggio Emilia approach—Advanced reflections* (2nd ed., pp. 49–97). Ablex Publishing.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook* (3rd ed.). SAGE Publications.

OECD. (2021). *AI in Education: Promises and Challenges*. OECD Publishing.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Parette, H. P., Quesenberry, A. C., & Blum, C. (2010). Missing the boat with technology usage in early childhood settings: A 21st-century view of developmentally appropriate practice. *Early Childhood Education Journal, 37*(5), 335–343. https://doi.org/10.1007/s10643-009-0352-x

Piaget, J. (1952). *The origins of intelligence in children*. International Universities Press.

Robinson, K. (2020). *Out of our minds: The power of being creative* (3rd ed.). Capstone.

Setyaningsih, D., Handasah, R. R., Mamma, A. T., Krobo, A., Olua, E., & Iryouw, V. (2024). Fostering Eco-literacy and Naturalistic Intelligence through Environmentally Based Education in Coastal Preschool. In *Proceedings of the International Conference on Early Childhood Education (ICECE)*. Jakarta: UNJ.

Sobel, D. (2004). *Place-based education: Connecting classrooms and communities*. Orion Society.

Solichah, N., & Shofiah, N. (2023). AI Literacy in Early Childhood Education: A Scoping Review. *Psikologika: Jurnal Pemikiran dan Penelitian Psikologi, 29*(2), 105–122. https://doi.org/10.20885/psikologika.vol29.iss2.art1

Torrance, E. P. (2018). *The nature of creativity*. Cambridge University Press.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wells, N. M., & Lekies, K. S. (2021). Nature and the life course: Pathways from childhood nature experiences to adult environmentalism. *Children, Youth and Environments, 31*(1), 96–118. https://doi.org/10.7721/chilyoutenvi.31.1.0096

Wilson, R. A. (2018). *Nature and young children: Encouraging creative play and learning in natural environments* (3rd ed.). Routledge.

Wilson, R. A. (2018). *Nature and young children: Encouraging creative play and learning in natural environments* (3rd ed.). Routledge.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–where are the educators? *International Journal of Educational Technology in Higher Education, 16*(1), 39. https://doi.org/10.1186/s41239-019-0171-0

This is an open-access article under the CC BY-SA license.
Copyright © 2024 by Author