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SCHOOLYARDS AS BUILT INFRASTRUCTURE: A FEASIBILITY FRAMEWORK FOR CLOSING ENVIRONMENTAL EDUCATION IMPLEMENTATION GAPS

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ABSTRACT

Environmental education (EE) is widely promoted as a response to climate change, biodiversity loss, and sustainability challenges, with schools identified as critical settings for fostering children's engagement with nature. However, despite increasing policy attention and expanding initiatives, the implementation of school-based environmental education remains fragmented and difficult to sustain. This paper argues that these limitations are not primarily pedagogical, but structural, institutional, and spatial, rooted in the everyday built and institutional environments of schools. Drawing on a narrative literature review of school-based environmental education initiatives, the study synthesises reported implementation challenges and organises them into six systemic categories: Professional Capacity Gap, Institutional Integration Gap, Learning Design–Accessibility Gap, Socio-Cultural and Equity Gap, Programme Design–Context Gap, and Evaluation and Evidence Gap. These challenges reveal persistent gaps between environmental education ambitions and the operational, organisational, and spatial realities of schools. In response, the paper presents two connected conceptual frameworks. The first establishes a conceptual enabling conditions framework with six conditions: Realistic Time Demand, Embedded Whole-School Practice, Student-Friendly Learning Design, Context-Responsive Inclusion, Locally Feasible Programme Design, and Observable Practice-Based Evidence, which function as a feasibility filter. The second translates these conditions into built-environment applications, positioning schoolyards and everyday school spaces as strategic infrastructure for sustained engagement with nature. The paper offers a practical lens for educators, school leaders, built-environment professionals, and policymakers to plan, evaluate, and scale more feasible and context-responsive environmental education initiatives.

Keywords: *Built Environment; Environmental Education; Implementation Feasibility; Nature Engagement; Schoolyards*

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1. INTRODUCTION

Environmental education (EE) is increasingly positioned as a core response to climate change, biodiversity loss, and long-term sustainability challenges (Akinsemolu & Onyeaka, 2025; Olsson et al., 2016). Schools are frequently identified as critical settings for fostering environmental awareness and encouraging children's engagement with the natural world (Christ et al., 2022). In this context, schoolyards and outdoor spaces are highlighted for their potential to support experiential and place-based learning (Hamilton & Marckini-Polk, 2023).

Despite this recognised potential, environmental education initiatives in schools frequently remain fragmented, short-lived, or peripheral to core educational practice. Many EE programmes rely on external funding, individual champions, or short-term projects, limiting their ability to become embedded within routine school life (Hamalosmanoğlu & Varinlioğlu, 2019; Sulsberger, 2018). Although existing research documents a wide range of EE practices and learning outcomes, considerably less attention has been paid to why such initiatives struggle to persist within everyday school environments (Hamilton & Marckini-Polk, 2023).

From a built environment perspective, schools are not neutral spaces for learning (Arghiani & Shakeri, 2021). They are complex systems shaped by spatial layouts, infrastructure provision, timetabling constraints, and institutional routines. These conditions directly influence how spaces, including schoolyards, are used and prioritised. Environmental education is often treated as an add-on, insufficiently aligned with the physical and organisational systems that govern everyday school operations (Nabirye, 2025).

In this study, school-based environmental education is framed as a feasibility challenge grounded in schools' built and institutional environments. This focuses particularly on schoolyards as routinely accessible spaces. This study asks: Under what conditions can environmental education and children's engagement with nature be realistically embedded and sustained within everyday school contexts? By addressing this question, this paper positions the built environment as a central consideration in environmental education planning.

2. METHODOLOGY

A narrative literature review (Baethge et al., 2019) was conducted to examine implementation challenges in school-based environmental education (EE) involving school-aged populations. Narrative reviews are widely used across disciplines to synthesise existing knowledge, identify recurring patterns, and support the development of conceptual frameworks (Baethge et al., 2019). The purpose of this review was to develop a conceptually grounded understanding of the conditions that influence the feasibility of embedding environmental education within everyday school environments, particularly through schoolyards, which are routinely accessible learning spaces. In addition to identifying systemic implementation challenges, the review also aimed to translate these conditions into built-environment applications that could support the practical operationalisation of environmental education within everyday school settings.

The literature search was conducted using Scopus, Web of Science, and Google Scholar. These databases were selected to ensure broad disciplinary coverage across

environmental education, sustainability education, school-based learning, and built environment research. The review focused on literature published between 2015 and 2025 to ensure relevance to contemporary environmental education practices, particularly in the context of the adoption of the Sustainable Development Goals (SDGs) in 2015 (Cai & Wolff, 2023).

Searches were performed using combinations of keywords including "environmental education", "education for sustainable development", "school-based environmental education", "implementation challenges", "barriers", "feasibility", "schoolyards", "outdoor learning", "children's connection with nature", "schoolyard design", "learning infrastructure", and "built environment".

Studies were included where they explicitly discussed implementation-level challenges affecting environmental education practices within schools, including both formal curricular and non-formal school-based initiatives. Attention was given to constraints related to programme planning, delivery, adaptation, continuity, and institutionalisation. Studies focused exclusively on higher education, the preschool level, programs outside the school system or non-school-based were excluded. Articles not available in English were also excluded.

An inductive thematic coding approach (Braun & Clarke, 2006) was used to identify recurring implementation patterns across the selected studies. Initially, specific implementation challenges directly reported in the literature were coded and organised into six challenge categories (Table 1). These categories were subsequently interpreted as holistic implementation gaps as presented in Table 1. Building on these gaps, a set of conceptual enabling conditions (Figure 1) was developed to articulate how environmental education, particularly nature-based engagement through schoolyards, could be feasibly embedded within routine school environments.

A second stage of abductive conceptual synthesis (Awuzie & McDermott, 2017) was then undertaken to develop the second framework (Table 2), and each enabling condition was examined through a built-environment lens to identify the spatial and infrastructural characteristics most likely to support its practical implementation.

Accordingly, this review adopts a conceptual and design-oriented approach to identify the foundational conditions necessary for feasible and sustained environmental education within everyday school systems.

3. REPORTED IMPLEMENTATION CHALLENGES IN SCHOOL-BASED ENVIRONMENTAL EDUCATION

Across the global literature, implementation challenges in school-based environmental education (EE) are characterised by a layered set of structural, institutional, and learner-level constraints rather than isolated barriers. At the instructional level, many studies report insufficient teacher knowledge of environmental and climate issues, limited pedagogical preparation for experiential or inquiry-based learning, and low confidence in facilitating outdoor or action-oriented activities (Cudworth, 2020; Hartley et al., 2023). These capacity gaps are compounded by heavy workloads, administrative pressures, and exam-driven accountability systems, which significantly restrict the time and flexibility required for environmental and outdoor learning (Boeve-de Pauw et al., 2019; Heras et

al., 2020; Wellman et al., 2025). As a result, even where teacher motivation exists, EE is often deprioritised within everyday classroom practice.

These instructional constraints are reinforced by rigid curricular structures and inadequate school-level resources (Masson et al., 2025). Across contexts, curricula are frequently described as overcrowded, academically oriented, and resistant to cross-curricular integration (Aguilar-Jurado et al., 2019; Walshe et al., 2023). This limits opportunities to meaningfully embed EE. Many schools also lack the physical infrastructure, green spaces, equipment, laboratories, ICT access, or waste-management systems necessary to support hands-on, place-based, or citizen-science activities (Nursofah et al., 2025; Tan et al., 2024). Consequently, environmental education is often implemented as fragmented, extracurricular, or short-term interventions rather than as a sustained whole-school practice embedded within core teaching and institutional routines (Balundė & Poškus, 2025; Bissinger & Bogner, 2018).

At an organisational and policy level, the literature consistently highlights weak institutional support as a major constraint. Programmes commonly operate under unstable funding conditions, limited staffing, high staff turnover, and insufficient management capacity, undermining continuity and scalability (Hasriyanti et al., 2025; Mulders et al., 2025; Sulsberger, 2018). Policy-level gaps, including weak enforcement of environmental regulations, inconsistent national priorities, and limited commitment from education authorities, further constrain long-term integration (Trott, 2022; Zhan et al., 2019). These challenges are worsened by practical disruptions such as scheduling conflicts, examinations, school events, strikes, and shifting institutional timelines, which frequently interrupt planned activities (Collins & O'Riordan, 2022; Willis & Schmidt, 2018). Many initiatives also lack an explicit programme theory or theory of change, making it difficult to align activities with intended outcomes or to generate systematic learning from implementation (Eichinger et al., 2022; Salazar et al., 2024).

Table 1: Mapping of the implementation challenges of environmental education practices in the global school context

Holistic Gaps	Implementation Challenges	Reference Examples
Professional Capacity Gap	IC01. Teacher Capacity Gaps	[1], [2], [3]
	IC02. Teacher Workload and Time Pressure	[4], [5], [6]
Institutional Integration Gap	IC03. Infrastructure and Resource Limitations	[7], [8]
	IC04. Curriculum Rigidity	[9], [10], [11]
	IC05. Fragmented Curriculum Integration	[12], [13]
	IC11. Institutional and Funding Instability	[14], [15], [16]
	IC22. Policy and Governance Gaps	[17], [18]
	IC23. Program Continuity and Logistics Disruptions	[19], [20]
	IC24. Weak Programme Theory	[21], [22]
Learning Design–	IC06. Student Cognitive and Language Barriers	[23], [24]
	IC07. Sustained Student Engagement Challenges	[25], [26]

Holistic Gaps	Implementation Challenges	Reference Examples
Accessibility Gap	IC19. Emotional and Affective Barriers	[27], [28], [29]
	IC25. Social Norms and Perceived Control Barriers	[30], [31], [32]
Socio-Cultural and Equity Gap	IC08. Family and Community Resistance	[33], [34]
	IC09. Socioeconomic Inequality and Access Gaps	[35], [36]
	IC10. Cultural and Power Constraints	[37], [38], [39]
	IC20. Knowledge System and Stakeholder Tensions	[40], [41]
	IC21. Limited Nature Access and Urbanisation	[42], [43]
Programme Design–Context Gap	IC12. Contextual Fit and Adaptation Challenges	[44], [45]
	IC13. Constraints on Outdoor and Field Learning	[46], [47]
	IC14. Technology Access and Reliability Barriers	[48], [49]
Evaluation and Evidence Gap	IC15. Evaluation and Data Collection Constraints	[50], [51]
	IC16. Impact Measurement Limitations	[52]
	IC17. Inconsistent Evidence Base	[53], [54]
	IC18. Behavioural Persistence Gaps	[55], [56]

[1] (Díaz et al., 2020); [2] (Hartley et al., 2023); [3] (Cudworth, 2020); [4] (Wellman et al., 2025); [5] (Heras et al., 2020); [6] (Boeve-de Pauw et al., 2019); [7] (Tan et al., 2024); [8] (Nursofah et al., 2025); [9] (Masson et al., 2025); [10] (Walshe et al., 2023); [11] (Aguilar-Jurado et al., 2019); [12] (Bissinger & Bogner, 2018); [13] (Balundė & Poškus, 2025); [14] (Hasriyanti et al., 2025); [15] (Sulsberger, 2018); [16] (Mulders et al., 2025); [17] (Trott, 2022); [18] (Zhan et al., 2019); [19] (Willis & Schmidt, 2018); [20] (Collins & O'Riordan, 2022); [21] (Salazar et al., 2024); [22] (Eichinger et al., 2022); [23] (Robledo & Prudente, 2022); [24] (Repetto et al., 2024); [25] (Delmas et al., 2024); [26] (Ampuero et al., 2014); [27] (Waite et al., 2016); [28] (Cornelisse & Sagasta, 2018); [29] (Sarrasin et al., 2022); [30] (Christ et al., 2022); [31] (Kwan et al., 2017); [32] (Ampuero et al., 2013); [33] (Nahar, 2024); [34] (Phillips et al., 2024); [35] (Jaime et al., 2023); [36] (Stevenson et al., 2018); [37] (Zhang et al., 2019); [38] (Schneller et al., 2022); [39] (Hoare & Higgins, 2022); [40] (Demneh & Zackery, 2023); [41] (Collier et al., 2023); [42] (Barthel et al., 2018); [43] (Liang et al., 2025); [44] (Bergman, 2016); [45] (Ray et al., 2015); [46] (Rollwagen-Bollens et al., 2022); [47] (Chen et al., 2025); [48] (Hamdan et al., 2023); [49] (Roy et al., 2025); [50] (Nekaris et al., 2018); [51] (Hutasoit et al., 2024); [52] (Keller et al., 2022); [53] (Pongsophon, 2025); [54] (Whitburn et al., 2023); [55] (Moghadam et al., 2022); [56] (Isenaj et al., 2025)

Learner-level challenges intersect with these structural constraints. Students often struggle with abstract concepts, technical language, and unfamiliar outdoor or scientific settings, leading to reduced comprehension, confidence, and perceived relevance (Repetto et al., 2024; Robledo & Prudente, 2022). Sustaining engagement over time is particularly difficult in rural, low-income, or marginalised contexts, and during periods of disruption such as the COVID-19 pandemic (Ampuero et al., 2014; Delmas et al., 2024). Emotional responses, including climate anxiety, fear, hopelessness, and aversion to certain species, are repeatedly identified as barriers that can inhibit engagement rather than motivate action (Cornelisse & Sagasta, 2018; Sarrasin et al., 2022; Waite et al., 2016). In addition, social norms, peer dynamics, and perceived lack of control over family, community, or economic conditions often limit students' capacity to translate learning into action (Ampuero et al., 2013; Christ et al., 2022; Kwan et al., 2017).

Environmental education initiatives are further shaped by broader social and cultural contexts. Several studies report resistance or limited support from parents and local communities due to conflicting norms, misinformation, or practical constraints (Nahar, 2024; Phillips et al., 2024). Socioeconomic inequalities and long-standing underinvestment in schools reduce both the reach and equity of EE programmes (Jaime et al., 2023; Stevenson et al., 2018). Cultural beliefs, power structures, and traditional practices, such as patriarchal norms, elders' authority, hunting traditions, or consumerist values, conflict with conservation objectives and restrict youth agency (Hoare & Higgins, 2022; Schneller et al., 2022; Zhang et al., 2019). Tensions between formal and informal learning spaces, modern scientific approaches and indigenous knowledge systems, and differing stakeholder values further complicate programme design and legitimacy (Collier et al., 2023; Demneh & Zackery, 2023).

Contextual and logistical constraints also recur across regions. Urbanisation, reduced access to natural spaces, and changing lifestyles limit children's everyday contact with nature (Barthel et al., 2018; Liang et al., 2025). This weakens the baseline experiential connections. Designing programmes that are adaptable across diverse regions, cultures, age groups, and learning needs remains challenging, with materials often criticised as either too locally specific, overly theoretical, or excessively complex (Bergman, 2016; Ray et al., 2015). Outdoor and field-based activities are constrained by weather, safety concerns, travel logistics, and institutional risk aversion, while technology-based tools face barriers related to cost, device access, usability, digital literacy, and technical reliability (Chen et al., 2025; Hamdan et al., 2023; Rollwagen-Bollens et al., 2022).

Finally, the literature identifies persistent challenges in generating evidence and assessing impact. Data collection and evaluation are frequently constrained by cultural biases in instruments, delays in ethics approval, small sample sizes, weak methodological designs, and heavy analytical demands on educators and researchers (Hutasoit et al., 2024; Nekaris et al., 2018). Even where data are available, quantifying long-term impacts, such as sustained behaviour change, carbon reductions, or environmental outcomes, remains difficult (Keller et al., 2022). As a result, evidence on the effectiveness of school-based EE is often inconsistent. It often reports mixed or modest effects across knowledge, attitudes, behaviours, wellbeing, and connection to nature (Pongsophon, 2025; Whitburn et al., 2023). Many programmes struggle to move beyond short-term awareness toward durable, real-world pro-environmental practices (Isenaj et al., 2025; Moghadam et al., 2022). This underscores a persistent implementation gap in environmental education initiatives within formal school contexts globally.

4. CONCEPTUAL FRAMEWORK: ENABLING CONDITIONS FOR FEASIBLE ENVIRONMENTAL EDUCATION IN SCHOOLYARDS

4.1 FRAMEWORK OVERVIEW, SYSTEMIC LOGIC, AND FEASIBILITY LENS

To overcome the reported challenges in Chapter 3, the proposed framework conceptualises school-based environmental education as a built-environment and systems challenge rather than a programme-delivery problem. Reported implementation challenges are interpreted as manifestations of broader structural conditions that shape what schools can realistically initiate, sustain, and institutionalise within everyday practice. From this perspective, implementation difficulties are not isolated barriers but

indicators of systemic misalignments between environmental education ambitions and schools' spatial, institutional, and operational capacities.

To make these dynamics explicit, the framework synthesises reported implementation challenges into a set of holistic implementation gaps, recurring mismatches between environmental education initiatives and how schools function as routine environments. These gaps demonstrate that the persistence of implementation challenges is not due to a lack of environmental education activity but to insufficient alignment with school timetables, governance structures, pedagogical realities, socio-cultural contexts, and evaluation mechanisms (Figure 1). Rather than linking environmental education directly to learning or behavioural outcomes, the framework introduces conceptual enabling conditions as a feasibility filter. These conditions clarify the circumstances under which environmental education and routine engagement with nature can be embedded within everyday school environments, shifting attention from what environmental education aims to achieve to what schools are structurally able to sustain.

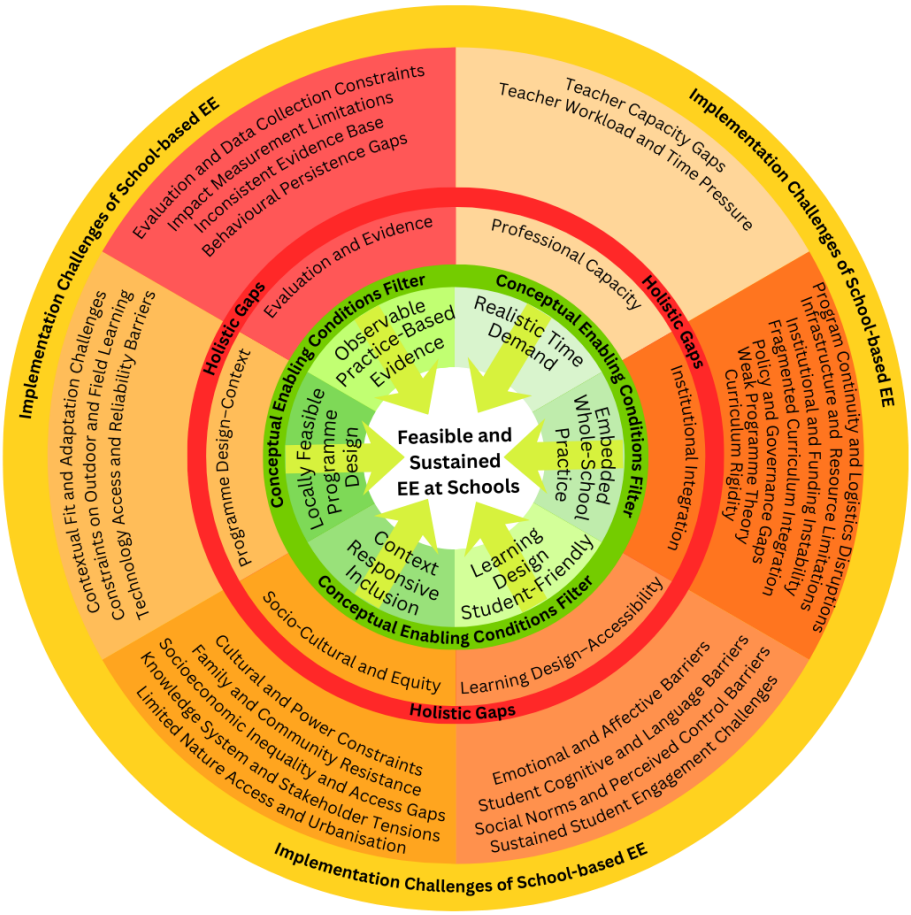

Figure 1: Conceptual framework linking implementation challenges, systemic gaps, and enabling conditions

Six systemic gaps were identified through the synthesis (Table 1). A Professional Capacity Gap reflects limitations in teacher knowledge, confidence, training, and workload capacity. An Institutional Integration Gap arises from rigid curricula, fragmented delivery, weak policy alignment, and limited organisational support. A Learning Design - Accessibility Gap is linked to cognitive, emotional, and engagement-

related barriers among students. A Socio-Cultural and Equity Gap is shaped by family expectations, community norms, cultural contexts, and structural inequalities. A Programme Design - Context Gap reflects poor alignment between intervention design and local spatial, infrastructural, and institutional realities. Finally, an Evaluation and Evidence Gap are associated with weak monitoring practices, inconsistent evidence, and limited feedback into decision-making processes. Together, these gaps indicate that implementation challenges persist not because environmental education is absent, but because initiatives are insufficiently aligned with the everyday functioning of schools as institutional and spatial systems.

In response, through the framework in Figure 1, this paper proposes, six corresponding conceptual enabling conditions: Realistic Time Demand, ensuring alignment with school schedules, routines, and workload constraints; Embedded Whole-School Practice, integrating environmental education into governance, culture, and daily operations rather than treating it as an add-on; Student-Friendly Learning Design, prioritising accessibility, developmental appropriateness, and emotional support; Context-Responsive Inclusion, recognising socio-cultural, ecological, and equity conditions; Locally Feasible Programme Design, aligned with available infrastructure and spatial resources; and Observable Practice-Based Evidence, generating visible outputs that support reflection, continuity, and institutional learning. These enabling conditions do not prescribe specific interventions. Instead, they articulate minimum feasibility requirements for embedding environmental education in routine school practice.

To achieve these enabling conditions, how the built environment in schools can support is worth investigating. By shifting the analytical focus from programme effectiveness to structural feasibility and offering a built-environment–informed lens for understanding, section 4.2 examines the conditions under which environmental education can be sustained within everyday school systems.

4.2 SCHOOLYARDS AS EVERYDAY BUILT INFRASTRUCTURE: A BUILT ENVIRONMENT TRANSLATION FRAMEWORK

The second framework (Table 2) was developed through a conceptual translation of the six enabling conditions identified in Figure 1 into built-environment applications. While Figure 1 explains the systemic conditions required for the feasibility of environmental education within formal school systems, Table 2 addresses how these conditions can be operationalised through the design, allocation, maintenance, and management of everyday school environments. This translation was informed by recurring spatial and infrastructural constraints identified across the reviewed literature.

Accordingly, Realistic Time Demand is strengthened when nature engagement is embedded within routine circulation and daily school movement rather than requiring additional travel or scheduling (Cenić et al., 2023). Embedded Whole-School Practice becomes more feasible when environmental education is integrated into maintenance systems, supervision patterns, and shared school operations (Karaarslan-Semiz & Sund, 2026). Student-Friendly Learning Design depends on safe, visible, shaded, and accessible spaces that support repeated use, while Context-Responsive Inclusion requires school environments that reflect local ecology, cultural relevance, equity, and learner diversity (Blanchet-Cohen & Reilly, 2013; van Dijk-Wesselius et al., 2020). Locally Feasible Programme Design depends on low-maintenance, infrastructure-compatible environmental learning spaces (van Dijk-Wesselius et al., 2020), while Observable

Practice-Based Evidence is strengthened by visible ecological change and student participation in environmental monitoring (Ballard et al., 2017).

Moreover, this paper argues that the schoolyards have the potential to simultaneously reduce multiple implementation barriers. As routinely accessible spaces, schoolyards minimise reliance on external logistics, reduce financial and administrative burdens, enable repeated low-cost use, and align with existing supervision arrangements and timetabling structures (van Dijk-Wesselius et al., 2020). This positions schoolyards particularly well-suited to supporting sustained engagement with natural elements within school settings (Andersen et al., 2015; Martin, 2003).

Table 2: Conceptual built environment translation framework for feasible school-based environmental education

Enabling Condition	Built Environment Translation
Realistic Time Demand	Nature engagement embedded within routine circulation and daily school movement
Embedded Whole-School Practice	Environmental education integrated into maintenance systems, supervision patterns, and shared school operations
Student-Friendly Learning Design	Safe, visible, shaded, accessible, and developmentally appropriate learning spaces
Context-Responsive Inclusion	School spaces reflecting local ecology, cultural relevance, equity and learner diversity
Locally Feasible Program Design	Low-maintenance, infrastructure-compatible, and spatially practical environmental learning spaces
Observable Practice-Based Evidence	Visible ecological change and student participation in environmental monitoring

In contrast to field trips, externally delivered programmes, or one-off environmental activities, which typically require additional time, funding, permissions, transport, and coordination, schoolyards function within existing institutional rhythms (Behrendt & Franklin, 2014; Bergin et al., 2024). Their integration into daily supervision, timetabling, and maintenance structures enables repetition, continuity, and cumulative learning, conditions that are difficult to achieve through sporadic interventions. Integrated green spaces and visible ecological functions also strengthen whole-school environmental practice by embedding sustainability within institutional planning, supervision, and maintenance systems (Blanc et al., 2025), while safe, shaded, and accessible outdoor environments improve student participation, emotional comfort, and developmental suitability for repeated engagement (Bergin et al., 2024; Waite et al., 2016).

However, the framework explicitly recognises that schoolyards or built environmental aspects alone are insufficient. Their capacity to support environmental education is realised only when the identified enabling conditions are in place, ensuring alignment with institutional routines, pedagogical design, socio-cultural contexts, and organisational capacity. As an example, visible biodiversity monitoring, restoration spaces, and student-led environmental observation may strengthen continuity and

institutional learning by making environmental education outcomes tangible within everyday school life (Christ et al., 2022; Howe et al., 2025; Masson et al., 2025). In this context, children's connection with nature is understood not as an abstract psychological outcome, but as regular exposure and repeated interaction with natural elements embedded within everyday school life, made possible through structurally aligned, spatially supportive, and context-responsive educational systems.

5. CONCLUSIONS

This paper demonstrates that the persistent challenges in school-based environmental education are not primarily pedagogical shortcomings, but reflections of deeper structural, institutional, and spatial misalignments within everyday school systems. By synthesising implementation challenges across the global literature, the study shows that environmental education often remains fragmented because it is insufficiently aligned with how schools function as built and organisational environments. In response, two connected conceptual frameworks are proposed. The first identifies six systemic implementation gaps and translates them into six enabling conditions that function as a feasibility filter for embedding environmental education and routine engagement with nature within daily school life. The second translates these enabling conditions into built-environment application principles, showing how schoolyards and everyday school spaces can support feasibility through accessible, low-maintenance, and institutionally integrated design. Positioning schoolyards as everyday built infrastructure offers a practical pathway for repeated, low-cost engagement with nature; however, their potential depends on alignment with institutional routines, pedagogical design, socio-cultural context, and organisational capacity. For the built environment field, this highlights the importance of recognising schoolyards as strategic educational assets. Future research should empirically test and refine both frameworks across diverse school contexts to support more durable and context-responsive environmental education.

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