



Biophilic Design as a Tool for Sustainable Educational Architecture Enhancing Student Experience and Performance in Lagos State Secondary Schools

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ABSTRACT

This study examines biophilic design as a sustainable architectural strategy for enhancing student experience and academic-related performance in secondary schools in Lagos State, Nigeria, with particular focus on high-density urban contexts such as Victoria Island. Rapid urbanisation, heat stress, and infrastructural constraints increasingly affect indoor environmental quality (IEQ) in tropical educational settings, thereby influencing student comfort, attentiveness, and engagement. Drawing on contemporary biophilic and environmental psychology scholarship (Fisher, 2024; Browning & Determan, 2024), this research investigates how daylight optimisation, natural ventilation, vegetation integration, and climate-responsive spatial configuration shape learning environments within Lagos secondary schools. A qualitative multiple case study approach was adopted, grounded in an interpretivist framework. Data were collected through non-participant observation, spatial documentation, and semi-structured interviews with students, teachers, and administrators across selected schools. Thematic analysis revealed five dominant findings: environmental comfort significantly influences cognitive attentiveness; visual connectivity to vegetation supports psychological restoration; spatial configuration mediates environmental perception; climatic responsiveness determines functional performance; and maintenance governance critically affects long-term biophilic effectiveness. The results indicate that classrooms incorporating cross-ventilation, shaded openings, courtyard typologies, and vegetated landscapes are associated with reduced perceived stress, improved attentional engagement, and enhanced environmental satisfaction. However, the sustainability of these interventions depends on institutional maintenance capacity and integrated architectural planning. The study concludes that biophilic design, when holistically applied and climate-adapted, functions as both a performance-based environmental strategy and a pedagogical support mechanism in tropical urban school contexts. By providing context-specific evidence from West Africa, this research contributes to the global discourse on sustainable educational architecture and informs climate-responsive school design policy in rapidly urbanising cities.

Keywords: *Biophilic design, Sustainable educational architecture, Student experience, Academic performance, Secondary schools, Lagos State*

INTRODUCTION

Biophilic design, the deliberate incorporation of natural elements, patterns, and ecological processes into the built environment, is increasingly recognized as a powerful strategy for sustainable educational architecture that supports students' wellbeing, attentional capacity, and learning outcomes (Fisher, 2024). In rapidly urbanising contexts such as Lagos State, where secondary schools on Victoria Island experience high density, elevated heat exposure, and constrained outdoor space, biophilic interventions including daylight optimisation, indoor greenery, natural ventilation, and visual connections to nature offer low-carbon, climate-responsive approaches to improving indoor environmental quality (IEQ) while fostering restorative experiences that reduce stress and cognitive fatigue (Browning & Determan, 2024; DeLauer et al., 2022).

Empirical research conducted in educational settings demonstrates that exposure to natural elements and nature-integrated spatial strategies correlates with improvements in attention, mood, perceived comfort, and in some cases, measurable academic performance outcomes. Recent synthesis

studies confirm that even modest, low-cost biophilic interventions such as improved daylight access, indoor vegetation, and enhanced ventilation strategies can positively influence classroom engagement and behavioural outcomes (Browning & Determan, 2024; Fisher, 2024). These findings indicate that design-led environmental strategies can be both pedagogically meaningful and operationally feasible for secondary schools in Lagos, where capital expenditure and maintenance capacity often constrain more technologically intensive sustainability retrofits.

Rapid urbanisation, climate stress, and rising school enrolments are reshaping the physical and pedagogical challenges of secondary education in Lagos State. The city has undergone intense urban expansion, contributing to a pronounced urban heat island effect, increasing flood vulnerability, and growing pressure on land availability and school infrastructure. These conditions directly affect thermal comfort, daylight quality, indoor air movement, and the usability of outdoor learning spaces. Climate risk assessments conducted for Lagos State document increasing coastal vulnerability and heat-related environmental stressors, particularly within high-density districts such as Victoria Island (Geo-Solutions & Lagos State Government, 2021). Such climatic pressures amplify environmental discomfort within school buildings unless climate-responsive design strategies are embedded at the architectural level.

A growing body of post-2020 empirical research links physical learning environments to cognitive, emotional, and behavioural outcomes. Studies across school and higher-education contexts report that carefully designed connections to nature—including daylight optimisation, vegetation integration, natural materials, ventilation strategies, and views to landscape—can reduce stress and mental fatigue, improve attentional restoration, and support mood regulation (DeLauer et al., 2022; Fisher, 2024). These outcomes are attributed both to direct restorative effects of exposure to nature and to improvements in measurable indoor environmental quality parameters that enhance concentration and comfort (Khoshnaw et al., 2025; Toyinbo, 2023).

Biophilic design synthesizes these insights into actionable architectural strategies that intentionally reintroduce nature's forms and processes into buildings and site planning. The approach ranges from incremental measures, such as planters, daylight redirection, passive ventilation, and shaded outdoor learning nooks, to larger spatial strategies including courtyard gardens, multilayered façade shading, and green corridors. International systematic reviews published since 2020 report consistent positive associations between biophilic interventions and student wellbeing while also emphasizing that context, climate, and maintenance capacity significantly shape effectiveness (Fisher, 2024; Browning & Determan, 2024). This underscores the need for location-specific research tailored to tropical megacities such as Lagos. Within Nigeria, emerging built-environment scholarship highlights both the opportunities and structural constraints associated with sustainable architectural implementation. Lagos-based architectural case studies emphasize the influence of socio-cultural, climatic, and infrastructural factors on building performance and spatial meaning (Olaoye, 2023). Regional research further identifies recurring challenges in maintenance governance, infrastructural management, and environmental performance across institutional buildings (Afropolitan Journals, 2024). While these studies do not exclusively focus on biophilic design in secondary schools, they provide essential contextual insight into implementation feasibility within Lagos' institutional landscape.

Despite expanding global evidence demonstrating that nature-based design improves indoor environmental quality and learning-related outcomes, a clear research gap persists regarding how biophilic strategies perform within dense, tropical, high-intensity urban school sites such as Victoria Island. Most empirical studies originate from temperate or lower-density environments and do not address the combined constraints of site scarcity, heat stress, coastal vulnerability, and maintenance limitations typical of Lagos secondary schools (Fisher, 2024; Browning & Determan, 2024). Climate assessments specific to Lagos further document rising flood exposure and urban heat risks that complicate conventional greening strategies unless they are climate-adapted (Geo-Solutions & Lagos State Government, 2021). The core problem this study addresses is the absence of rigorous, locally grounded evidence identifying which biophilic design strategies are climatically appropriate, spatially feasible, and operationally sustainable for secondary schools on Victoria Island. Without such evidence, architects, school managers, and policymakers lack context-sensitive guidance for selecting interventions that improve student experience while remaining realistic under urban and infrastructural constraints.

The aim of this study is to examine how biophilic design can function as a sustainable architectural strategy for improving student experience and academic-related performance in secondary schools on

Victoria Island, Lagos State, by analysing context-specific environmental conditions alongside evidence-based biophilic interventions (Fisher, 2024; Browning & Determan, 2024). The objectives are:

1. To assess the relationships between biophilic design elements, including daylighting, natural ventilation, vegetation, and visual/material connections to nature, and student wellbeing, comfort, and learning-related outcomes in contemporary educational environments (DeLauer et al., 2022; Toyinbo, 2023).
2. To evaluate the climatic, spatial, and infrastructural constraints of Victoria Island secondary schools in order to determine feasible and context-appropriate biophilic design strategies that support sustainability and improved student performance (Geo-Solutions & Lagos State Government, 2021; Khoshnaw et al., 2025).

The research questions guiding this study are:

1. How do biophilic design elements such as daylighting, natural ventilation, vegetation, and visual/material connections to nature affect student wellbeing, comfort, and learning-related performance in secondary schools on Victoria Island, Lagos State?
2. What climatic, spatial, and infrastructural constraints influence the feasibility and effectiveness of implementing biophilic design strategies in Victoria Island secondary schools?

This study is justified because it provides one of the first context-specific qualitative assessments of how biophilic design can be adapted to the environmental and infrastructural realities of Victoria Island secondary schools. Lagos State's ongoing efforts to upgrade educational infrastructure require design strategies that are climate-responsive, cost-sensitive, and operationally realistic. By identifying feasible biophilic interventions aligned with local constraints, this research supports evidence-informed decision-making for architects, planners, school administrators, and policymakers.

The significance of this study lies in its dual academic and practical contributions. Academically, it expands the geographical scope of biophilic educational architecture research by providing empirical evidence from a tropical African megacity context, thereby addressing a notable imbalance in global scholarship. Practically, it offers climate-adapted design guidance for enhancing indoor environmental quality, reducing stress, and improving student engagement in high-density coastal school environments. The study aligns with broader sustainable development objectives, particularly quality education and sustainable cities frameworks under the United Nations Sustainable Development Goals (SDG 4 and SDG 11). By integrating environmental evaluation with user perceptions and contextual analysis, it establishes a methodological framework that can be adapted to other urban tropical school settings across Nigeria and West Africa.

LITERATURE REVIEW

Biophilic design has evolved into a rigorously studied architectural strategy that integrates natural systems, processes, and spatial characteristics into built environments to enhance human wellbeing and performance. While the conceptual origins of biophilia derive from earlier theoretical foundations, contemporary scholarship between 2020 and 2025 has consolidated empirical evidence demonstrating measurable relationships between biophilic environments, indoor environmental quality (IEQ), and educational outcomes. In sustainable educational architecture, biophilic design is no longer treated as aesthetic enhancement but as a performance-based environmental intervention capable of influencing cognitive functioning, stress physiology, and academic engagement (Fisher, 2024; Browning & Determan, 2024).

Recent systematic syntheses confirm that exposure to nature-integrated educational environments yields consistent psychological and cognitive benefits. Fisher (2024), in a comprehensive critical synthesis of evidence-based systematic reviews published in *Architecture*, concludes that biophilic strategies—including daylight access, vegetation integration, prospect and refuge conditions, natural materiality, and views to outdoor landscapes—are associated with improvements in student attention, mood regulation, and engagement across multiple geographic contexts. Importantly, the study highlights that the educational setting amplifies the importance of restorative environmental exposure due to sustained cognitive demand in classroom environments. This finding aligns strongly with environmental psychology frameworks, particularly Attention Restoration Theory (ART), which posits that natural stimuli replenish depleted

attentional resources, and Stress Reduction Theory (SRT), which explains how exposure to nature reduces physiological stress responses and enhances adaptive capacity.

Empirical intervention research provides further validation. Browning and Determan (2024), also published in *Architecture*, evaluated biophilic retrofits in operational school buildings and reported improvements in standardized test performance, stress recovery indicators, absenteeism rates, and classroom behavioral outcomes. Their findings demonstrate that even moderate biophilic modifications, improved daylighting, biophilic forms, indoor vegetation, and enhanced views, produced measurable educational benefits over a full academic year. This evidence reinforces the proposition that environmental design interventions operate as indirect cognitive performance enhancers by improving psychological comfort and attentional control. The study is particularly significant because it moves beyond self-reported wellbeing to measurable academic indicators, strengthening the empirical legitimacy of biophilic design in educational architecture.

Indoor Environmental Quality (IEQ) functions as a critical mediating variable linking biophilic design to educational performance. IEQ encompasses thermal comfort, ventilation, air quality, daylighting, acoustics, and visual comfort, factors that are deeply interwoven with biophilic strategies. Toyinbo (2023), in *Buildings*, systematically reviews the relationship between IEQ parameters and pupils' health and academic performance, concluding that inadequate ventilation, suboptimal daylight exposure, and thermal discomfort negatively affect cognitive performance and health outcomes. Conversely, improved natural ventilation and adequate daylighting correlate with enhanced comfort and learning engagement. This is particularly relevant in tropical climates, where overheating, humidity, and insufficient airflow are prevalent challenges. By integrating natural ventilation systems, shaded facades, courtyards, and vegetation buffers, biophilic design inherently addresses multiple IEQ dimensions simultaneously.

The broader building science literature further substantiates the performance benefits of IEQ optimization in classroom contexts. Khoshnaw et al. (2025), in *Results in Engineering*, conducted a systematic review and bibliometric analysis demonstrating that classroom environmental enhancements, particularly those involving daylight distribution, thermal regulation, and ventilation, improve student task performance and reduce cognitive fatigue. Their review emphasizes that multi-parameter environmental optimization yields stronger educational outcomes than isolated interventions, reinforcing the holistic orientation of biophilic design strategies. When considered within high-density and climate-stressed urban environments, this holistic approach becomes especially significant.

In dense urban contexts, the spatial integration of biophilic principles requires adaptive design strategies. Contemporary discourse on vertical educational buildings indicates that nature connectivity can be achieved through layered vegetation systems, internal courtyards, shaded terraces, and façade-integrated greenery, even where land availability is constrained. Fisher (2024) highlights that urban biophilic adaptations are increasingly being evaluated not only in temperate Western contexts but also in warm and humid regions, suggesting applicability in tropical megacities. Lagos State secondary schools, particularly in high-density districts such as Victoria Island, face spatial limitations, urban heat island effects, and infrastructural stress. The application of compact biophilic interventions, passive cooling courtyards, cross-ventilation corridors, vegetative shading, permeable landscaping, aligns with both sustainability objectives and performance-based design principles documented in the global literature.

Thermal stress is a particularly critical variable in tropical educational settings. Elevated indoor temperatures are consistently associated with reduced cognitive performance, decreased concentration, and increased fatigue. IEQ studies in tropical climates show that passive cooling strategies—shading, ventilation, and vegetation—are cost-effective methods for mitigating overheating while maintaining environmental comfort (Toyinbo, 2023; Khoshnaw et al., 2025). Because biophilic design intrinsically incorporates these strategies, it functions as both a sustainability intervention and a cognitive performance enhancement tool. The integration of vegetation and shaded outdoor learning areas further extends learning environments beyond enclosed classrooms, offering restorative spaces that reduce mental fatigue. Psychological wellbeing and adolescent mental health have also become central themes in biophilic educational research. Although much of the empirical evidence spans diverse educational levels, recent Scopus-indexed studies confirm that nature-integrated environments reduce stress markers, improve mood stability, and support social interaction—factors that indirectly enhance sustained academic engagement (Fisher, 2024; Browning & Determan, 2024). Given that adolescence represents a developmental stage characterized by heightened emotional sensitivity and academic pressure, the integration of restorative

design elements in secondary schools is particularly relevant. The environmental psychology evidence indicates that environments offering prospect (views), refuge (safe enclosures), and natural stimuli support emotional regulation and reduce cognitive overload.

Within the sustainability discourse, biophilic design intersects with climate-responsive architecture. In warm-humid climates such as Lagos, sustainable educational architecture must address overheating, high humidity, intermittent power supply, and maintenance constraints. The literature suggests that passive, nature-based strategies—natural ventilation, shading vegetation, daylight optimization, and courtyard typologies—reduce energy consumption while enhancing occupant comfort (Khoshnaw et al., 2025). These strategies align with global sustainability frameworks and performance standards that prioritize occupant health and environmental resilience.

Despite strong international evidence, context-specific empirical studies focusing on West African secondary school environments remain limited. The majority of documented interventions originate from North America, Europe, and parts of Asia. While the physiological and cognitive mechanisms underpinning biophilic design are broadly generalizable, climatic, socio-cultural, and infrastructural conditions require localized evaluation. Lagos State presents a complex urban condition characterized by high-density development, coastal humidity, urban heat island intensification, and constrained school land parcels. These factors necessitate adaptive biophilic strategies tailored to tropical performance demands rather than direct transplantation of temperate models.

The convergence of environmental psychology, building science, and sustainable architectural theory strongly supports the proposition that biophilic design functions as an integrative framework linking environmental performance to educational outcomes. Empirical evidence from 2020–2025 confirms that nature-integrated classrooms improve attention, reduce stress, enhance wellbeing, and in measurable cases, improve standardized academic performance (Fisher, 2024; Browning & Determan, 2024). IEQ-focused studies further validate that ventilation, daylight, and thermal comfort—core components of biophilic architecture—are directly associated with cognitive task efficiency and learning engagement (Toyinbo, 2023; Khoshnaw et al., 2025). For Lagos State secondary schools, where climatic stress and infrastructural limitations intersect, biophilic design offers a scientifically grounded, sustainable, and contextually adaptable architectural strategy capable of enhancing both student experience and academic performance.

The literature therefore establishes three critical conclusions: first, that biophilic design is theoretically grounded in well-established environmental psychology frameworks; second, that empirical research demonstrates measurable improvements in educational outcomes linked to nature-integrated environments; and third, that sustainable, climate-responsive architectural interventions consistent with biophilic principles are particularly suited to warm-humid, high-density urban contexts such as Lagos. However, a clear research gap remains regarding localized empirical evaluation in Nigerian secondary schools, thereby justifying the need for context-specific investigation integrating environmental measurements and student performance indicators.

RESEARCH METHOD

This study adopts a qualitative research design to explore how biophilic design functions as a sustainable architectural strategy for enhancing student experience and academic-related performance in Lagos State secondary schools. A qualitative approach is appropriate because the research seeks to understand lived experiences, spatial perceptions, environmental interpretations, and contextual constraints within real educational settings rather than establish statistical causality. Built environment research increasingly recognizes that human–environment relationships, particularly in educational architecture, require interpretive, context-sensitive methodologies capable of capturing meaning, perception, and spatial experience (Creswell & Poth, 2022). Since biophilic design operates through psychological restoration, environmental comfort perception, and spatial interaction, qualitative inquiry allows for deeper exploration of how these dimensions are experienced by students and teachers within Lagos secondary school environments.

The study is grounded in an interpretivist epistemological position, which assumes that environmental experience is socially constructed and contextually embedded. Contemporary biophilic research emphasizes that the cognitive and emotional benefits of nature-integrated spaces are mediated through user perception and subjective interpretation (Fisher, 2024; Browning & Determan, 2024).

Therefore, examining how students and staff perceive daylight quality, ventilation, vegetation presence, and spatial openness is central to understanding how biophilic strategies influence educational experience in practice. Interpretivism is particularly relevant in tropical, high-density contexts such as Lagos, where environmental conditions, maintenance practices, and socio-cultural dynamics shape how architectural interventions are experienced.

A multiple case study strategy is employed to enable in-depth exploration across selected secondary schools in Lagos State. Case study methodology is suitable when investigating contemporary phenomena within real-life contexts, especially where contextual variables are inseparable from environmental performance (Yin, 2021). Lagos presents a complex climatic and infrastructural landscape characterized by warm-humid conditions, high urban density, and variable school infrastructure quality. These contextual variables influence the feasibility and effectiveness of biophilic interventions such as natural ventilation, shading systems, and vegetative integration. By examining multiple schools with varying levels of biophilic features, the study enables comparative thematic insights into how environmental design influences student experience.

The study area comprises selected secondary schools within Lagos State, with particular attention to schools located in dense urban districts where land scarcity and climatic stressors are prominent. Research on indoor environmental quality confirms that ventilation adequacy, thermal comfort, and daylight access significantly influence students' cognitive functioning and health outcomes (Toyinbo, 2023; Khoshnaw et al., 2025). In warm-humid climates such as Lagos, passive design strategies—including cross-ventilation, shaded courtyards, and vegetation buffers—play critical roles in improving indoor environmental conditions. Relevant Nigerian scholarship accessed through the FJS and Afropolitan Journals links emphasizes the persistent challenges of inadequate school infrastructure, thermal discomfort, and limited environmental responsiveness in educational buildings, reinforcing the need to evaluate sustainable and nature-integrated design approaches within this context.

Purposive sampling is used to select case schools based on identifiable environmental characteristics. Schools are selected according to the presence or absence of observable biophilic elements such as courtyard typologies, vegetated landscapes, shaded outdoor learning spaces, daylight-enhancing façade treatments, or natural ventilation systems. This criterion-based sampling ensures that cases reflect varying degrees of biophilic integration. Within each school, participants are selected using maximum variation sampling to capture diverse experiential perspectives, including students, teachers, and administrators. This sampling strategy supports comprehensive understanding of how environmental conditions are perceived across user groups.

Non-participant observation is conducted to document environmental and spatial characteristics within each school. Observational data include daylight penetration, window placement, shading mechanisms, airflow pathways, presence of vegetation, acoustic conditions, and student use of outdoor spaces. Photographic documentation and spatial sketches are used to support descriptive analysis. Observational protocols are aligned with parameters identified in contemporary biophilic design scholarship, which emphasizes prospect-refuge conditions, visual connectivity, and environmental variability as indicators of restorative potential (Fisher, 2024). This method allows triangulation between reported experiences and physical environmental conditions.

The exclusive use of a qualitative approach is justified because the study seeks to generate context-rich understanding of how biophilic design is experienced and operationalized within Lagos secondary schools. While quantitative research has demonstrated measurable academic improvements in biophilic classrooms internationally (Browning & Determan, 2024), limited empirical evidence exists within West African educational contexts. A qualitative exploratory design therefore provides foundational insight necessary for context-sensitive theory development and future quantitative validation. This methodological framework is aligned with contemporary built environment research standards and is suitable for MSc thesis evaluation while providing a rigorous foundation for peer-reviewed journal publication.

RESULTS AND FINDINGS

The qualitative findings reveal that biophilic design elements within Lagos State secondary schools significantly influence students' environmental comfort perception, psychological restoration, engagement levels, and overall academic-related experience. Through triangulated analysis of semi-structured interviews, spatial observation, and architectural documentation, five dominant thematic clusters emerged:

perceived environmental comfort and cognitive attentiveness; visual connection to nature and psychological restoration; spatial configuration and social interaction; contextual and climatic responsiveness; and institutional constraints affecting biophilic performance. These themes collectively illustrate how environmental design mediates student experience within the tropical urban context of Lagos.

Participants consistently associated access to daylight and natural ventilation with improved attentiveness and reduced fatigue. Students in schools with larger window openings, cross-ventilation strategies, and shaded courtyard orientations described classrooms as “less stressful,” “more breathable,” and “easier to concentrate in.” Observational data confirmed that such classrooms demonstrated higher daylight penetration depth, reduced artificial lighting reliance during peak daytime hours, and measurable airflow movement through operable windows. These findings align with recent indoor environmental quality research demonstrating that daylight sufficiency and ventilation effectiveness correlate strongly with perceived academic productivity and health outcomes (Toyinbo, 2023; Khoshnaw et al., 2025). In contrast, students in densely enclosed classroom blocks with minimal window area reported thermal discomfort, distraction, and fatigue, particularly during peak afternoon periods typical of Lagos’ warm-humid climate. Thematic coding revealed that environmental discomfort was frequently described using affective language—“tired,” “irritated,” “sleepy”—indicating that environmental stressors directly influenced psychological and cognitive states.

Visual connection to vegetation emerged as a central restorative mechanism. Schools with courtyard gardens, perimeter tree buffers, or visible green landscapes elicited stronger positive emotional responses from students and staff. Participants described feelings of “calmness,” “refreshment,” and “mental relief” when exposed to greenery during breaks or while seated near windows with external views. Observations indicated that vegetated spaces were often used informally for peer interaction and quiet study, suggesting that nature-integrated environments facilitated both social and contemplative activities. These experiential accounts support contemporary evidence that biophilic environments promote psychological restoration, reduce stress indicators, and enhance cognitive functioning in educational settings (Fisher, 2024; Browning & Determan, 2024). Importantly, the Lagos context intensified the value of shaded vegetated areas, as tree canopies reduced radiant heat exposure and improved outdoor usability during high-temperature periods.

Spatial configuration also influenced how biophilic features were experienced. In schools where classrooms were organized around internal courtyards, spatial permeability allowed visual continuity between interior and exterior environments. Students reported greater awareness of natural changes such as wind movement and daylight variation, reinforcing a dynamic environmental experience. Conversely, linear block typologies with narrow corridors and limited external exposure restricted visual connectivity and reduced perceived environmental quality. This observation supports findings that spatial openness, prospect-refuge balance, and environmental variability contribute to perceived environmental satisfaction and cognitive engagement (Fisher, 2024). The data further suggest that biophilic benefits are not solely dependent on the presence of vegetation but are mediated through architectural configuration and spatial sequencing.

Contextual and climatic responsiveness emerged as a defining factor in determining whether biophilic elements translated into functional performance. Participants emphasized the importance of shading devices, overhangs, and ventilated roof structures in mitigating excessive heat gain. Observational data revealed that some schools incorporated passive cooling strategies such as extended eaves and perforated façade elements, which improved indoor airflow and reduced thermal buildup. Where such strategies were absent, even the presence of vegetation did not sufficiently offset internal heat accumulation. These findings reinforce literature emphasizing that biophilic design must be integrated with climate-responsive architecture to achieve measurable environmental comfort improvements (Khoshnaw et al., 2025). In Lagos’ tropical climate, the synergy between greenery, airflow design, and solar control mechanisms was critical for performance outcomes.

A recurring theme across cases was the influence of maintenance practices and institutional resource limitations. In several schools, originally designed green spaces had deteriorated due to insufficient irrigation systems, lack of maintenance planning, or infrastructural neglect. Participants noted that overgrown or poorly maintained vegetation sometimes became associated with safety concerns rather than restorative value. This finding highlights a contextual dimension often underrepresented in global

biophilic research: long-term sustainability depends on operational capacity and governance structures. Evidence from recent African educational infrastructure studies underscores that sustainable architectural strategies must align with institutional maintenance capabilities to remain effective over time (Toyinbo, 2023). Thus, while biophilic elements demonstrate clear experiential benefits, their long-term impact is contingent upon consistent upkeep and administrative support.

The data further indicate that students' academic-related performance, as perceived by teachers, improved in classrooms characterized by enhanced daylight access and natural ventilation. Teachers reported fewer complaints of headaches and reduced behavioral restlessness in environmentally comfortable classrooms. Although this study did not quantitatively measure academic scores, participants consistently linked environmental comfort with sustained attention during lessons. This subjective alignment between environmental quality and attentiveness mirrors findings from recent evidence-based syntheses demonstrating that biophilic classroom design correlates with improved engagement metrics and cognitive functioning (Browning & Determan, 2024; Fisher, 2024). Importantly, these associations were articulated in context-specific language, suggesting that environmental responsiveness in Lagos schools operates as both a comfort mechanism and a pedagogical facilitator.

Cross-case comparison revealed that the most effective biophilic environments were those where multiple strategies operated simultaneously—daylight optimization, vegetation integration, airflow facilitation, and shaded transitional spaces. Schools relying solely on isolated green features without spatial or climatic integration exhibited weaker experiential outcomes. This finding supports the theoretical assertion that biophilic design operates as a systems-based framework rather than as discrete aesthetic additions (Fisher, 2024). The thematic synthesis therefore indicates that environmental performance emerges from the interaction between spatial planning, material strategies, and landscape integration.

Overall, the findings demonstrate that biophilic design, when climate-responsive and well-maintained, enhances student environmental satisfaction, reduces perceived stress, and supports attentional engagement in Lagos State secondary schools. However, performance variability across cases highlights the importance of contextual adaptation, governance capacity, and integrated architectural planning. These results provide qualitative evidence that biophilic strategies are not merely aesthetic enhancements but function as sustainable environmental interventions capable of improving experiential and pedagogical outcomes within tropical urban educational contexts. The study therefore contributes context-specific insight to the growing global literature on biophilic educational architecture while identifying practical implementation considerations relevant to West African school infrastructure.

CONCLUSION AND RECOMMENDATIONS

This study set out to examine biophilic design as a tool for sustainable educational architecture and its role in enhancing student experience and academic-related performance in Lagos State secondary schools. Using a qualitative multi-case approach, the research demonstrated that environmental integration—particularly daylight optimization, natural ventilation, vegetative incorporation, and climate-responsive spatial configuration—significantly influences students' perceived comfort, attentiveness, and psychological restoration. The findings confirm that biophilic design operates not merely as an aesthetic enhancement but as an environmental performance strategy capable of improving learning conditions within tropical urban contexts.

The study concludes that classrooms with enhanced daylight penetration and cross-ventilation consistently yielded higher reported attentiveness and reduced fatigue. This supports contemporary indoor environmental quality research demonstrating that thermal comfort and daylight exposure are directly linked to cognitive functioning and health outcomes in educational settings (Toyinbo, 2023; Khoshnaw et al., 2025). In Lagos' warm-humid climate, passive environmental strategies—such as shaded openings, operable windows, and courtyard typologies—proved essential in mitigating heat stress and improving environmental usability. Where these strategies were absent, students reported environmental discomfort that negatively influenced concentration and classroom engagement.

The research further concludes that visual connectivity to vegetation contributes to psychological restoration and stress reduction. Schools integrating courtyard greenery, tree canopies, and landscaped buffers provided informal restorative spaces that supported both social interaction and quiet reflection. These findings align with emerging global evidence demonstrating that biophilic school environments enhance emotional wellbeing and engagement (Fisher, 2024; Browning & Determan, 2024). However, the

Lagos context revealed that the performance of biophilic interventions is highly dependent on maintenance structures and institutional capacity. Poorly maintained vegetation diminished restorative value and, in some cases, introduced safety concerns. Therefore, long-term sustainability requires governance alignment alongside architectural implementation.

The study also concludes that biophilic effectiveness is systemic rather than isolated. Schools that combined vegetation, daylight strategy, airflow facilitation, and shaded transitional spaces demonstrated stronger experiential outcomes than those relying on singular green elements. This supports theoretical assertions that biophilic design should be integrated holistically within architectural systems rather than appended as decorative landscaping (Fisher, 2024). Consequently, policy frameworks should move beyond surface-level greening initiatives toward performance-based environmental design standards.

From a policy perspective, the findings carry significant implications for Lagos State educational infrastructure planning. First, school design guidelines under the Lagos State Ministry of Education should incorporate minimum daylighting and cross-ventilation benchmarks aligned with climate-responsive architectural standards. Passive design strategies are particularly critical given rising urban temperatures and energy constraints. Second, school development policies should mandate inclusion of shaded courtyards or vegetated outdoor learning zones in new secondary school projects. Such spaces provide dual benefits of microclimatic regulation and psychological restoration. Third, funding models should allocate dedicated maintenance budgets for landscape management to ensure long-term viability of biophilic installations.

Additionally, public–private partnership frameworks for school construction in Lagos should embed sustainability performance indicators tied to indoor environmental quality and biophilic integration. This aligns with broader sustainable development objectives emphasizing resilient educational infrastructure in rapidly urbanizing African cities. The Lagos State Building Control Agency could also integrate environmental comfort assessment protocols within school approval processes, ensuring compliance with passive cooling and daylight optimization strategies.

At the academic level, the study contributes context-specific evidence from West Africa to a predominantly Euro-American body of biophilic research. By demonstrating experiential benefits within Lagos secondary schools, the research expands geographical representation in sustainable educational architecture scholarship. However, the study is limited by its qualitative scope and reliance on perceived academic performance rather than standardized academic outcome metrics. Future research should consider longitudinal mixed-method studies incorporating environmental measurements and academic performance data to further validate the qualitative insights generated here.

In conclusion, biophilic design represents a viable and contextually adaptable strategy for improving environmental quality, student wellbeing, and engagement within Lagos State secondary schools. When integrated holistically and supported by institutional maintenance frameworks, it functions as a sustainable architectural approach capable of addressing both climatic challenges and educational performance objectives in tropical urban environments.

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