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Integrating Sustainable Building Materials and Biophilic Strategies for Mental Health-Supportive Educational Architecture in Lagos State, Nigeria

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Abstract- ***Educational buildings in Nigeria are seldom designed with student mental health as an explicit parameter, despite known links between indoor conditions, exposure to nature, and student wellbeing. This study examines how sustainable building materials and biophilic design can be integrated into educational architecture in Lagos State to support student mental health while reducing embodied carbon. A desk-based narrative synthesis of peer-reviewed literature, institutional case studies, and built-environment reports, published largely between 2018 and 2026, was conducted. Passive design and low-carbon materials are shown to reduce energy use by up to 50 percent relative to conventional cement-based construction, while biophilic interventions are consistently associated with reduced psychological distress and improved cognitive performance, including a 54 percent reduction in distress recorded on a Lagos university campus. Indoor Environmental Quality, covering thermal comfort, air quality, and daylight access, emerges as the variable mediating much of this relationship. Adoption in Lagos State's educational buildings nonetheless remains fragmented, constrained by high material costs, weak regulatory enforcement, and limited professional awareness. The study recommends treating Indoor Environmental Quality as a deliberate design parameter, weighting procurement toward low-carbon materials, and embedding biophilic design within architecture curricula.***

Keywords: Biophilic Design, Educational Architecture, Indoor Environmental Quality (IEQ), Low-Carbon Materials, Mental Health, Sustainable Architecture

I. INTRODUCTION

The construction industry is one of the biggest emitters of carbon emissions in the world, and the same applies to the materials used to construct schools and universities. Conventional cement-based construction has been found to have a very high embodied carbon cost, leading to the search for other materials like stabilised earth blocks, bamboo composites and recycled aggregates (Daramola, Ajayi, & Ayodele, 2025). In addition to this material change, architects have begun to embrace biophilic design by introducing daylighting, vegetation, natural ventilation and water elements into the built environment, based on the premise that humans have an innate need to be in contact with nature (Kaplan and Kaplan, 1989; Kellert, Heerwagen and Mador, 2008).

In the context of educational buildings, the case for combining these two approaches is enhanced by the magnitude of the student mental health issue. According to the World Health Organization and UNICEF (2024), at least one out of every seven adolescents (10–19 years) has a mental health disorder, such as anxiety and depression. The results of the studies conducted outside Nigeria indicate that the physical learning environment is not neutral setting to this problem. Yin, Zhu, MacNaughton, Allen, and Spengler (2018) conducted a randomised crossover study and discovered that a biophilic indoor space reduced SBP by 8.6 mmHg, and enhanced short-term memory by 14 percent compared to a non-biophilic control space. Browning and Determan (2024) cite a Baltimore school that transformed one math classroom using the biophilic design approach that led to measurable stress recovery in a year, which inspired the design of a whole elementary school. Similar improvements in test scores and student mood were reported by Determan et al. (2019).

The construction industry in Nigeria has been less proactive in responding to the evidence, even though

it has a variant of the same issue. Rapid urbanisation, high energy demand, and the continued use of constructions materials, most notably cement and sandcrete block, with high carbon footprints and low control of internal temperatures without mechanical cooling systems, are challenges facing the built environment of Lagos State (Ajayi, Daramola, & Ayodele, 2024; Dimuna, Ekhaese, Mercy, Akinola, & Ndimako, 2025). In Lagos, the high-rise condominiums have a high rate of thermal discomfort of occupants, while passive building design solutions like orientation, materials and natural ventilation have been found to partially alleviate the thermal discomfort in these buildings, but are underutilized (Dimuna et al., 2025). Daramola, Ajayi and Ayodele (2025) also conducted a systematic review of 53 studies and found that although sustainable materials and circular economy concepts are increasingly the subject of academic research in Nigeria, their uptake in practice is hindered by factors such as cost, inadequate regulatory enforcement, and low awareness among stakeholders. Also, Ogunnaike, Kalu, and Eze (2025) conducted a separate review of buildings in Nigeria and reported that less than 20 percent of the institutional buildings they were surveyed on make use of biophilic elements beyond merely daylighting.

Caleb University in Imota, Lagos, has produced some of the more direct evidence on this question within an educational setting. Adegbolafunmi, Ogidiagba, Tejumaiye, Akinyemi, and Dayomi (2024) documented biophilic interventions across the university's campus and linked them to improvements in student wellbeing, while a more recent quantitative study by Ademakinwa, Savage, Ajayi, Akhigbe, and Ogunnaike (2026) measured psychological restoration directly: students in zones of the Caleb University campus classified as high in biophilic character showed a 54 percent reduction in psychological distress compared with students in low-biophilic zones, with perceived restorativeness statistically accounting for most of that effect. At the level of individual buildings, Asaju, Onamade, Chukwuka, Odefadehan, and Alagbe (2024) linked Indoor Environmental Quality in architecture studio spaces directly to students' academic performance, and Babamboni, Emmanuel-Obot, Ebo, Okolo, and Ibitoye (2026) extended a comparable line of enquiry to urban park settings in Lagos, again finding a measurable relationship between environmental characteristics and user wellbeing.

These studies indicate that the underlying relationship between sustainable, biophilic design and student mental health is not in serious doubt, at least at the level of individual interventions or single campuses. What is missing is synthesis and the integration of sustainable materials, biophilic approaches and Indoor Environmental Quality as one design problem instead of each being a design agenda of its own, for the design of educational architecture in Lagos State. Most of the Nigerian studies conducted so far have focused on sustainability and biophilia separately (Akinyemi, Adewole, & Tejumaiye, 2024) and very few studies have explored what such an integrated approach to sustainability, low carbon, and mental health support might look like for a school or university building rather than a house, hotel, or office. This gap has practical implications, especially when the psychological stress already reported in Nigeria among students is taken into consideration and the proliferation of new educational buildings being constructed in Lagos State.

This study addresses that gap through a desk-based synthesis of the literature, structured around four objectives:

1. To assess the extent to which sustainable building materials and biophilic strategies are currently integrated into academic building design in Lagos State.
2. To examine the relationship between biophilic design elements and student mental health in educational buildings.
3. To analyse the contribution of Indoor Environmental Quality to mental health outcomes in learning environments.
4. To evaluate how low-carbon design approaches can be integrated into educational architecture in Lagos State going forward.

II. MATERIALS AND METHODS

The method used in this study is a desk-based narrative synthesis method, not primary data collection. The decision is based on the brief to consolidate existing evidence on the use of sustainable materials, biophilic design and Indoor Environmental Quality (IEQ) in relation to education architecture in Lagos State and not to create new measurements.

The sources were identified using Google Scholar, ResearchGate, African Journals Online and the publication archives of the journals known to publish built-environment research in Nigeria were also consulted, namely the African Journal of Environmental Sciences and Renewable Energy, the International Journal of Environmental Research and Earth Science, the International Journal of Sustainable Development and Planning, the International Journal of Research and Innovation in Applied Science, and Energy & Buildings. The search terms that were used included "sustainable building materials", "biophilic design", "indoor environmental quality", "educational architecture", and "mental health", with the addition of "Lagos" or "Nigeria". The publications of the department of architecture of the Caleb University were searched specifically and each publication was cross-checked individually with the setting of this study for authenticity and currency, before being included.

Publications from 2018 to 2026 were given priority to ensure the evidence base was up to date, except for three publications. The three authors (Kaplan and Kaplan, 1989; Ulrich, 1984; and Kellert, Heerwagen and Mador, 2008) were retained because they pre-date this period, but still form the conceptual foundations of the theory of biophilic design and have been referenced in the current Nigerian literature examined here.

A source was considered if it discussed at least one of three areas: sustainable or low carbon building materials, biophilic design and IEQ, in relation to an educational, institutional or directly comparable building type and with priority given to studies in Nigeria and especially Lagos State. Studies confined to residential or purely commercial buildings were retained only where they offered material- or design-level findings transferable to an educational context, such as embodied carbon figures or passive cooling performance data.

Findings were not subjected to statistical formal meta-analysis but were grouped thematically, as the underpinning studies are diverse in design, sample size and outcome measure, and hence cannot be meaningfully pooled. In the process, four recurring themes emerged: sustainable and low carbon materials, biophilic design and psychological outcomes, IEQ as a mediator variable, and the barriers of adoption in the context of Lagos. The following Results and Discussion are organised around these themes.

This review is a secondary, desk-top study, a process that does not produce new primary measurements of embodied carbon, IEQ or psychological outcomes. All figures reported in the Results and Discussion section are drawn directly from the cited primary studies and should be read as estimates specific to those studies' own samples and methods, rather than as values established independently here. This is stated as an explicit limitation of the design adopted.

III. RESULTS AND DISCUSSION

Sustainable and Low-Carbon Building Materials

Across the Nigerian literature reviewed, sustainable materials and passive design strategies are consistently reported to outperform conventional cement-based construction. Ajayi, Daramola, and Ayodele (2024), in a systematic review of 32 studies on Nigerian housing, found that passive design features combined with materials such as ceiling insulation and reflective finishes reduced energy use by 30 to 50 percent, with experimental data from Kaduna showing indoor temperature reductions of approximately 3°C once roof insulation and reflective paint were applied. Dimuna, Ekhaese, Mercy, Akinola, and Ndimako (2025) reported a comparable pattern for high-rise residential buildings in Lagos, where building orientation and material choice were identified as practical levers for improving occupant

thermal comfort in the absence of mechanical cooling.

A larger, 53-study systematic review by Daramola, Ajayi, and Ayodele (2025) assessed the comparative effectiveness of three sustainability strategies in Nigerian architecture and found low-carbon passive design solutions to be the most effective (70 percent), ahead of sustainable materials adoption (65 percent) and circular economy measures (50 percent). Materials such as bamboo, laterite, compressed earth blocks, and recycled concrete were repeatedly identified as reducing embodied carbon and improving thermal performance relative to cement-based construction, although the review also found that high upfront cost and the absence of standardised guidance remain the principal constraints on their wider use.

Although none of these three studies was conducted in a school or university setting, the underlying physics of material performance, namely thermal mass, insulation value, and reflectivity, applies equally to classrooms and lecture halls, which in Lagos State are frequently single-storey or low-rise structures exposed to comparable solar loads. Table 1 summarises the reported performance of the main strategies identified in the literature reviewed.

Table 1: Reported Performance of Sustainable Material and Low-Carbon Design Strategies in Nigerian Studies

Strategy / Material	Reported Effect	Source
Ceiling insulation, reflective finishes, shading (passive design)	Energy use reduced by 30–50%; indoor temperature reduced by approximately 3°C in field trials	Ajayi, Daramola, & Ayodele (2024)
Building orientation and material selection in high-rise residential construction	Improved occupant thermal comfort; reduced reliance on mechanical cooling	Dimuna, Ekhaese, Mercy, Akinola, & Ndimako (2025)
Bamboo, laterite, compressed earth blocks, recycled concrete	Reduced embodied carbon and improved thermal performance relative to cement-based construction	Daramola, Ajayi, & Ayodele (2025)
Low-carbon passive design strategies overall (53-study systematic review)	Highest documented effectiveness among strategies assessed (70%), against 65% for sustainable materials and 50% for circular economy measures	Daramola, Ajayi, & Ayodele (2025)

Biophilic Design and Psychological Outcomes

The evidence linking biophilic design to psychological outcomes is stronger and more direct than the materials evidence, partly because several of the studies reviewed measured mental health outcomes explicitly rather than as a secondary inference. The most directly relevant finding comes from Caleb University itself. Ademakinwa, Savage, Ajayi, Akhigbe, and Ogunnaike (2026) used the Perceived Restorativeness Scale and the Depression Anxiety Stress Scales across 100 students stratified into high, moderate, and low biophilic campus zones, and found that zone classification explained the great majority of variance in mental health outcomes, with students in high-biophilic zones reporting 54 percent less psychological distress than those in low-biophilic zones. Their analysis also found that perceived restorativeness, the subjective sense that an environment allows mental recovery from fatigue, accounted for most of this effect statistically, which suggests the mechanism is less about the presence of greenery as such and more about whether students experience the space as restorative.

This finding is consistent with international evidence. Yin, Zhu, MacNaughton, Allen, and Spengler (2018) recorded measurable physiological recovery, lower

blood pressure and improved short-term memory, after brief exposure to biophilic indoor settings in a randomised crossover design. Browning and Determan (2024) and Determan et al. (2019) document a comparable pattern in a school setting specifically: a biophilic classroom redesign in Baltimore produced better stress recovery and improved test scores within a single academic year, results that were subsequently carried over into the design of an entire new elementary school. Table 2 sets out the biophilic elements most frequently associated with these outcomes across the studies reviewed.

Table 2: Biophilic Design Elements and Associated Psychological and Cognitive Outcomes

Biophilic Element	Reported Outcome	Source
Daylighting, natural ventilation, indoor vegetation (general indoor exposure)	Lower blood pressure (8.6 mmHg systolic); 14% improvement in short-term memory	Yin, Zhu, MacNaughton, Allen, & Spengler (2018)
Campus-level biophilic zoning (water features, green corridors, vegetation density)	54% reduction in psychological distress in high- versus low-biophilic zones; perceived restorativeness accounted for most of the effect	Ademakinwa, Savage, Ajayi, Akhigbe, & Ogunnaike (2026)
Classroom-level biophilic redesign (natural patterns, complexity and order, dynamic light)	Improved stress recovery and test scores within one academic year	Browning & Determan (2024); Determan et al. (2019)
Indoor Environmental Quality in studio/classroom settings	Direct association with students' academic performance	Asaju, Onamade, Chukwuka, Odefadehan, & Alagbe (2024)

At the building level, Asaju, Onamade, Chukwuka, Odefadehan, and Alagbe (2024) found a direct relationship between Indoor Environmental Quality in architecture studio spaces and students' academic performance, which links the materials and biophilic strands of this review more concretely to the educational context that is this study's specific concern. Their finding that studio environments with poorer IEQ were associated with lower academic performance suggests the relationship documented at the campus scale by Ademakinwa et al. (2026) also operates within individual buildings and rooms, not only across a campus as a whole.

Indoor Environmental Quality as the Mediating Variable

Taken together, the materials and biophilic evidence point toward Indoor Environmental Quality as the variable that connects the two. Thermal comfort, air quality, daylight access, and acoustic conditions are shaped directly by material choice, and they are also the dimensions through which biophilic elements such as natural ventilation, daylighting, and vegetation exert their psychological effects. Ogunnaike, Kalu, and Eze (2025), in their systematic review of biophilic and passive design strategies across Nigerian architecture, frame IEQ explicitly as the mechanism by which both strategies improve occupant wellbeing, rather than as a separate, third factor running alongside them.

This framing matters for educational buildings specifically because students spend extended, largely fixed periods of time in classrooms and studios, with limited ability to leave an uncomfortable space, unlike, for example, a hotel guest or office worker. A classroom with poor thermal comfort or inadequate daylight is therefore likely to compound its effects over the course of a school day in ways that shorter-duration building types do not experience to the same degree.

Adoption Gaps and Barriers in Lagos State

Despite this evidence base, adoption of sustainable materials and biophilic design in Lagos State's educational buildings remains limited. Ogunnaike, Kalu, and Eze (2025) found that fewer than 20 percent of surveyed institutional buildings in their sample incorporated biophilic features beyond basic daylighting, and that regulatory enforcement of sustainable material standards was weak. Adegbolafunmi, Ogidiagba, Tejumaiye, Akinyemi, and Dayomi (2024) reached a similar conclusion when examining Caleb University's own campus, noting that biophilic interventions had been implemented unevenly rather than as part of a coordinated design strategy.

The barriers identified across the literature cluster around three issues: the higher upfront cost of low-carbon materials compared with conventional sandcrete and cement block (Daramola, Ajayi, & Ayodele, 2025); limited awareness of biophilic design principles among practising architects, most of whom are trained primarily in conventional construction methods (Akinyemi, Adewole, & Tejumaiye, 2024); and the absence of policy incentives or building codes that specifically reward sustainable or biophilic features in publicly funded educational buildings (Ogunnaike, Kalu, & Eze, 2025). None of these barriers is unique to Nigeria, but their combined effect in a context of rapid school and campus construction means that buildings being completed now are likely to remain in use, and to shape the daily environment of students, for several decades.

IV. CONCLUSION

This review brings together evidence on sustainable building materials, biophilic design, and Indoor Environmental Quality that has, until now, largely been examined separately within the Nigerian architecture literature. The case for integration is strong: low-carbon materials and passive design strategies measurably reduce energy demand and improve thermal comfort, while biophilic elements are consistently associated with reduced psychological distress and improved cognitive performance, including in a direct, quantitative study conducted on a Lagos university campus. Indoor Environmental Quality functions as the variable linking the two, since it is shaped by material choice and is also the channel through which biophilic interventions affect occupants psychologically. Educational buildings present a particularly strong case for applying this integrated approach, given the extended, largely involuntary periods students spend in classrooms and studios and the scale of psychological distress already documented among young people. The evidence reviewed here also shows that adoption in Lagos State remains limited, constrained by cost, weak regulatory enforcement, and gaps in professional awareness rather than by any absence of supporting evidence. Closing that gap is therefore a matter of policy and practice rather than further proof of concept.

V. RECOMMENDATIONS

1. Lagos State Ministry of Physical Planning and Urban Development should require that Indoor Environmental Quality, covering thermal comfort, daylight access, and ventilation, be assessed and documented as a standard design parameter for new public educational buildings, rather than treated as a discretionary feature.
2. The Architects Registration Council of Nigeria and the Nigerian Institute of Architects should incorporate biophilic design and low-carbon material selection as core, examinable competencies within professional accreditation, rather than as optional continuing education content.
3. Procurement frameworks for publicly funded school and university construction should give explicit, weighted preference to low-carbon materials such as stabilised earth blocks and locally sourced timber, supported by cost-offsetting incentives given their higher upfront price relative to conventional sandcrete and cement block.
4. Architecture departments in Nigerian universities, including Caleb University, should treat biophilic design and Indoor Environmental Quality as a core component of design studio curricula, given the direct evidence linking studio environment to students' own academic performance.

5. Future research should move beyond single-campus or single-building case studies toward a coordinated, multi-site investigation across Lagos State's educational buildings, allowing the relationships identified here to be tested with primary measurement rather than secondary synthesis alone.

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