The Impact of Biophilic Interior Design on Pupil Well-being in Ugandan Primary Schools: A Convergent Mixed-Methods Study*

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ABSTRACT

A growing body of evidence links biophilic design to enhanced well-being in educational settings. However, this research is predominantly situated in high-income, developed countries, leaving a critical gap in understanding its effects in resource-constrained contexts. This study examined the effects of biophilic interior design on the emotional and social well-being of pupils in government-sponsored primary schools in Mukono District, Uganda. A convergent mixed-methods design was employed with 302 pupils (aged 11-12) from four purposively selected schools. Quantitative data were collected via a reliable 5-point Likert scale questionnaire (Cronbach's $\alpha = 0.895$) measuring Emotional and Social Environment (ESE) and perceptions of four biophilic domains: Nature in Space (NIS), Sensory Nature Stimuli (SNS), Nature of Space (NOS), and Natural Analogues (NA). Qualitative data were gathered through 12 focus group interviews (n=4 pupils each) incorporating diamond ranking and visual elicitation board activities. Quantitative data were analyzed using descriptive statistics, Spearman's correlation, and multiple regression. Qualitative data were analyzed using thematic analysis. The regression model was statistically significant, $F(4,297) = 74.34$, $p<.001$, explaining 49.4% of the variance in well-being scores (Adjusted $R^2=0.494$). All four biophilic domains were significant positive predictors, with NIS ($\beta = 0.54$, $p<.001$) and NOS ($\beta = 0.47$, $p<.001$) showing the strongest effects. Qualitative findings revealed that pupils strongly associated positive emotions with elements like natural light, views of greenery, and open, safe spaces for socializing, while expressing aversion to dark, paved, and poorly maintained environments. Biophilic design elements are powerful, significant predictors of pupil well-being in Ugandan primary schools. The convergence of quantitative and qualitative data provides robust, context-specific evidence that integrating these nature-based elements can profoundly enhance the emotional and social environment of learning spaces, offering a low-cost strategy for supporting holistic student development in resource-constrained settings.

Keywords: Biophilic Design, Pupil Well-being, Mixed-Methods, Educational Environments, Uganda, Sub-Saharan Africa, PERMA Framework.

INTRODUCTION

The physical environment of a school is not merely a container for learning but an active participant in the educational process (Barrett et al., 2015). Globally, there is a shifting paradigm towards designing learning spaces that support not only academic achievement but also the holistic well-being of students (Kanonire et al., 2022). Within this movement, biophilic design, an approach that seeks to connect building occupants more closely to nature, has emerged as a significant trend (Kellert et al., 2008). Rooted in the biophilia hypothesis, which posits an innate human affinity for the natural world (Wilson, 1984), biophilic design incorporates natural elements, materials, and forms into the built environment to improve health, well-being, and cognitive function.

Substantial research in developed contexts has demonstrated the benefits of biophilic elements in schools. Studies have linked access to natural light, views of vegetation, and the presence of plants to reduced stress,

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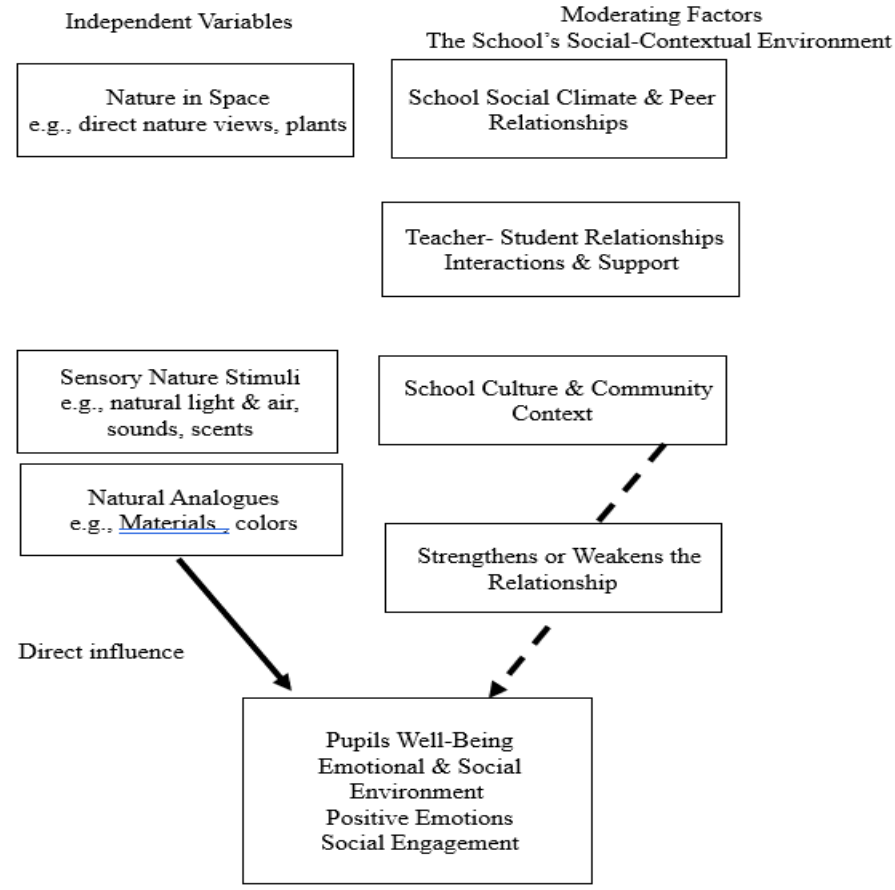
improved concentration, and enhanced student motivation (Browning & Determan, 2024; Li et al., 2019). Frameworks such as Kellert's (2018) patterns of biophilic design provide a structured way to categorize these elements, from direct experiences of nature (Nature in Space) to spatial configurations that evoke natural environments (Nature of Space).

However, a critical gap persists in the literature. The vast majority of this evidence comes from high-income countries in Europe, North America, and Asia, where sustainable design standards are often formally integrated into school infrastructure (Rolling & Gerhard, 2022). In contrast, the application and effects of biophilic design in government-sponsored, resource-constrained schools in Sub-Saharan Africa remain almost entirely unexplored. In Uganda, for instance, government schools often face challenges of overcrowding, poor lighting, and inadequate ventilation (Asad, 2021), yet the potential for low-cost, nature-integrated interventions to mitigate these issues and support pupil well-being is unknown.

Well-being, particularly in school contexts, extends beyond the absence of distress to include positive emotions, engagement, positive relationships, and a sense of comfort and safety (Seligman, 2012). In resource-constrained environments, where psychosocial stressors can be high, fostering school well-being is especially crucial.

The conceptual framework guiding this study integrates principles from Environmental Psychology and Biophilic Design Theory to hypothesize the relationships under investigation. As illustrated in Figure 1, the framework posits that four key biophilic domains—Nature in Space (NIS), Nature of Space (NOS), Sensory Nature Stimuli (SNS), and Natural Analogues (NA)—directly influence pupils' Emotional and Social Environment (ESE). Critically, drawing on the core tenets of Environmental Psychology, the model also proposes that this primary relationship is moderated by the school's social-contextual environment, including factors such as peer relationships, teacher-student interactions, and overall school culture. This framework allows for the examination of both the direct effects of biophilic design and the nuanced ways in which psychosocial factors may strengthen or weaken its impact on well-being in the Ugandan context.

Figure 1: Conceptual framework developed by the author to synthesize findings from this study



Therefore, this study aimed to fill this gap by examining the effects of biophilic interiors on the well-being of pupils in government-sponsored primary schools in Mukono District, Uganda. Using a convergent mixed-methods design, the study sought to answer the following research question: How do biophilic design elements influence the emotional and social well-being of pupils in Ugandan government-sponsored schools? By integrating quantitative measures of perception with rich qualitative insights from children themselves, this research provides a nuanced understanding of how nature-connected design can support the development of healthier, more supportive learning environments in a typically underrepresented context.

METHODS

Research Design

This study employed a convergent parallel mixed-methods design (Creswell & Plano Clark, 2018), involving the simultaneous collection of quantitative and qualitative data. The two strands were prioritized equally, analyzed separately, and then integrated during interpretation to provide comprehensive conclusions.

Study Setting and Participants

The study was conducted in four government-sponsored primary schools in Mukono District, Uganda, purposively selected to represent a range of contexts (rural, peri-urban, urban). Participants were Primary Six pupils aged 11-12 years, selected for their capacity for abstract reasoning and articulation (Otto et al., 2019). A census approach for this age group resulted in a total sample of 302 pupils (163 boys, 139 girls) (See Table 1).

Table 1. Demographic Characteristics of Participants (N=302)

School	**Number of Pupils (Aged 11-12)**	**Boys**	**Girls**
School A	64	30	34
School B	110	68	42
School C	25	12	13
School D	103	53	50
Total	**302**	**163**	**139**

Data Collection

Quantitative Data: A self-report questionnaire was administered to all 302 participants. It comprised:

- **Section A: Emotional and Social Environment (ESE).** An 8-item scale adapted from the PERMA framework (Seligman, 2012), rated on a 5-point Likert scale.
- **Section B: Biophilic Design Perceptions.** A 42-item scale measuring four domains from Kellert's (2018) framework: Nature in Space (NIS), Sensory Nature Stimuli (SNS), Nature of Space (NOS), and Natural Analogues (NA), also on a 5-point Likert scale. The overall questionnaire demonstrated excellent internal consistency (Cronbach's $\alpha = 0.895$).

Qualitative Data: Twelve focus group interviews (3 per school, 4 pupils each; n=48) were conducted. These semi-structured interviews incorporated:

- **Diamond Ranking:** Pupils ranked 9 photographs of biophilic attributes from most to least preferred.
- **Visual Elicitation Boards:** Pupils created collages of their "ideal school."

Data Analysis

- **Quantitative Analysis:** Data were analyzed using SPSS Version 30. Descriptive statistics, Spearman's correlation, and multiple linear regression were used.
- **Qualitative Analysis:** Thematic analysis was employed following Braun and Clarke (2006).

Ethical Considerations

Ethical approval was obtained from the Maseno University School of Graduate Studies and the Uganda Christian University Research Ethics Committee. Permission was sought from school administrators. Informed consent was obtained from parents/guardians, and assent was obtained from all child participants. Anonymity and confidentiality were maintained throughout the research process.

RESULTS

Quantitative Findings

Descriptive statistics indicated that the Emotional and Social Environment (ESE) was generally perceived positively (M=4.01). Among the biophilic domains, Nature in Space (NIS) had the highest mean score (M=3.72), while Natural Analogues (NA) had the lowest (M=3.46) (Table 2).

Table 2. Overall Mean Scores and Standard Deviations (N=302)

Variable	Number of Items	Overall Mean Score	Standard Deviation
Emotional & Social Environment (ESE)	8	4.01	1.23
Nature In Space (NIS)	10	3.72	1.48
Sensory Nature Stimuli (SNS)	10	3.64	1.45
Nature Of Spaces (NOS)	13	3.54	1.47
Natural Analogues (NA)	9	3.46	1.49

Spearman's correlation revealed significant positive relationships between all biophilic domains and ESE (Table 3). A multiple regression predicting ESE from the four biophilic domains was significant, $F(4, 297) = 74.34$, $p < .001$, Adjusted $R^2 = 0.494$. All Variance Inflation Factor (VIF) values were below 2.5, indicating no concerning multicollinearity (O'Brien, 2007). All four domains were significant positive predictors, with NIS ($\beta = 0.54$) and NOS ($\beta = 0.47$) as the strongest (Table 4) and (Figure 1)

Table 3. Spearman's Correlations between ESE and Biophilic Domains

Relationship	Spearman's ρ	P-value
ESE & NIS	0.43	< .01
ESE & NOS	0.29	< .05
ESE & SNS	0.27	< .05
ESE & NA	0.25	< .05
ESE & Overall Biophilic Exposure	0.39	< .01

Table 4. Multiple Regression Predicting ESE from Biophilic Domains

Predictor	**B**	**SE B**	**β**	**t**	**p**
(Constant)	0.85	0.11		7.73	< .001
NIS	0.54	0.05	0.54	10.80	< .001
NOS	0.47	0.05	0.47	9.40	< .001
SNS	0.28	0.05	0.28	5.60	< .001
NA	0.24	0.05	0.24	4.80	< .001

Note: Dependent Variable: ESE Score. $R^2 = .500$, Adjusted $R^2 = .494$.

The regression model confirms that biophilic design elements are, in aggregate, significant positive predictors of pupil well-being, collectively explaining a substantial portion of its variance (Adjusted $R^2 = 0.494$). However, this key figure itself indicates that the relationship is not purely deterministic. The fact that approximately 50% of the variance in well-being is attributable to factors outside our model provides clear quantitative evidence for the influence of other moderators.

These observed discrepancies challenge a simplistic application of Biophilic Design Theory and underscore a core tenet of Environmental Psychology: the impact of the physical environment is significantly moderated by psychosocial and contextual factors (Browning & Rigolon, 2019). A school's social climate, the quality of peer relationships, and teacher-student interactions are powerful forces that can potentially compensate for deficiencies in the physical environment or, conversely, mitigate the benefits of a nature-rich setting. This indicates that while biophilic design provides a foundational support for well-being, it is not a standalone solution and operates within a broader ecological system of the school.

The qualitative findings powerfully illuminate the 'why' behind both the strong aggregate correlation and these nuanced variations. Pupils did not merely acknowledge the presence of plants or light; they articulated how these elements directly fostered positive emotions

Qualitative Findings

Thematic analysis yielded five key themes:

1. **Visual Connection to Nature as a Source of Joy and Calm:** Views of greenery evoked happiness and provided a mental respite.
2. **Dynamic Light and Air as Foundational to Comfort:** Sunlight and fresh air were highly valued for creating a "happy" atmosphere and physical comfort.
3. **Transitional and Refuge Spaces for Social Well-being:** Verandas and shaded areas under trees were crucial for psychological adjustment, relaxation, and peer bonding.
4. **Natural Materials Fostering Authenticity and Ownership:** A distinct preference for natural materials (e.g., wooden desks) was linked to a sense of permanence and personal connection.
5. **Aversion to the Non-Biophilic:** Pupils strongly disliked dark classrooms and paved, barren playgrounds, describing them as "sad" and "hot."

DISCUSSION

This study provides compelling, multi-faceted evidence that biophilic design is a significant contributor to pupil well-being in Ugandan government-sponsored primary schools. The convergence of quantitative and qualitative data offers a robust and nuanced understanding of this relationship bridging a critical gap in the global literature on educational environments.

The central finding is that nearly half of the variance in pupils' emotional and social well-being (49.4%) can be predicted by their exposure to and perception of biophilic elements in their school environment. This large effect size (Adjusted R^2=0.494) is substantial for environmental psychology research and underscores the physical environment's critical role in the psychosocial experience of learning, particularly in a resource-constrained context. The regression model was robust, with no multicollinearity concerns, strengthening confidence in the results.

The quantitative results establish a clear hierarchy of impact: direct experiences of nature (NIS) and the spatial configuration of the environment (NOS) are the most powerful predictors. This aligns with global biophilic design theory, which emphasizes the primal importance of direct nature contact and spaces that evoke feelings of safety and prospect (Kellert, 2018; Browning et al., 2014). The strong performance of NOS is particularly noteworthy and offers a crucial contextual insight. While studies in high-income countries might highlight complex technological integrations of nature, our findings suggest that in Uganda, designing for "prospect" (e.g., open views for supervision) and "refuge" (e.g., secure, shaded verandas) is a highly cost-effective strategy. This supports and extends Mehta & Mahamood's (2022) work on the importance of transitional spaces.

The qualitative findings powerfully illuminate the psychological mechanisms behind these numbers. Pupils' articulations of feeling "happy," "calm," and socially connected in biophilic spaces resonate strongly with theories of restorative environments, such as Attention Restoration Theory (ART). The visual connection to nature (NIS) likely facilitates involuntary attention and mental fatigue recovery, while the refuge spaces (NOS) provide opportunities for social bonding and psychological safety, key components of the PERMA well-being framework (Seligman, 2012). The qualitative findings from this study powerfully illustrate these theoretical mechanisms in action. For instance, pupils' frequent expressions of feeling 'calm' and 'happy' when observing views of greenery from their classroom windows align directly with the rapid stress reduction proposed by Stress Recovery Theory (Ulrich, 1983). Similarly, their descriptions of using shaded areas under trees during break time 'to rest our minds' or 'to read when it is quiet' demonstrate how these natural spaces function as restorative environments, facilitating the recovery of directed attention as described by Attention Restoration Theory (Kaplan, 1995). Their aversion to non-biophilic elements reinforces the fundamental human need for nature-connected environments, as predicted by the biophilia hypothesis (Wilson, 1984).

From a practical standpoint, this research offers a clear, prioritized framework for action in Uganda and similar contexts. Prioritizing low-cost interventions that maximize Nature in Space (preserving existing trees, creating classroom gardens) and Nature of Space (ensuring classrooms have open views, creating and maintaining shaded verandas and seating areas) can yield significant dividends for pupil well-being. This study moves the conversation beyond theoretical benefits to provide actionable, evidence-based guidance for creating more nurturing learning environments where resources are scarce.

Limitations and Future Research

This study has several limitations. The cross-sectional design establishes relationship but not causality. The sample was confined to one district in Uganda, which may limit generalizability. Future research should employ longitudinal or experimental designs to track the causal effects of biophilic interventions on well-being and academic outcomes and expand to a wider geographical area. Furthermore, while the regression model identifies a strong predictive relationship, it is important to consider potential confounding variables that were not measured in this study. Factors such as teacher quality, pedagogical approaches, home environment, and individual pupil temperament could also influence well-being scores. Although the mixed-methods design and the high explanatory power of the model provide confidence in the central role of the physical environment, future studies would benefit from including these variables as covariates to paint an even more comprehensive picture of the determinants of pupil well-being.

CONCLUSIONS

This study demonstrates that biophilic design is not a luxury reserved for well-funded schools in the developed world, but a relevant and powerful strategy for enhancing the well-being of children in resource-constrained

environments. By showing that direct nature contact and thoughtful spatial design are the most significant predictors of emotional and social well-being, it provides a clear, prioritized framework for action. Integrating these principles into the design and retrofitting of Ugandan schools represents a low-cost, high-impact opportunity to invest in the holistic development of the nation's future generations. The voices of the pupils in this study offer a simple yet powerful conclusion: children thrive in schools that feel alive, connected to nature, and designed for their comfort and joy.

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