Beyond Pooled Averages: Sex-Patterned Variation in Biophilic School Experience among Ugandan Primary Pupils

Josephine Marete

Uganda Christian University, Uganda

DOI: https://doi.org/10.68050/JAMS.2026.511

Received: 17 Sept 2026; Accepted: 18 Sept 2026; Published: 22 September 2026

ABSTRACT

Biophilic school research commonly reports pooled pupil averages, potentially concealing whether particular groups experience the same environment differently. This exploratory secondary analysis used 302 questionnaires from four government-sponsored primary schools in Mukono District, Uganda (148 boys and 154 girls) to examine similarity and variation in reported well-being and four perceived biophilic domains. Welch unequal-variance tests, Cohen's d with 95% confidence intervals, Benjamini-Hochberg false-discovery-rate adjustment and a school- and age-adjusted sensitivity model were used. Four of five composite domains showed no statistically supported sex difference after multiplicity correction. Girls reported higher Emotional and Social Environment scores than boys (M=3.97 versus 3.77; d=.31, 95% CI [.08, .54]; FDR p=.039), although the school- and age-adjusted coefficient was smaller and imprecise (B=.140, 95% CI [−.002, .282]; HC3 p=.054). Five of 50 exploratory items survived FDR correction, all with small effects. The central message is broad similarity accompanied by a small set of contextual design questions. The findings support inclusive, participatory assessment of access, comfort and environmental use rather than sex-segregated design or assumptions of inherent female preference for nature.

Keywords: inclusive school design; biophilic environments; pupil experience; sex-disaggregated analysis; Uganda; environmental perception

INTRODUCTION

A school environment can be physically shared without being experienced uniformly. Daylight, seating, sensory contact, visibility and opportunities to explore are encountered through pupils' routines, peer relations, mobility, perceived safety and access to space. Nevertheless, biophilic school studies commonly report pooled averages. Pooled evidence is valuable for identifying general patterns, but it can conceal whether apparently supportive environments work equally well for different groups of children.

Sex-disaggregated analysis can therefore serve an inclusive-design purpose: not to establish fixed male and female preferences, but to identify where environmental access, comfort or use may vary. This distinction is important because small subgroup contrasts can easily be overinterpreted as biological difference, while a lack of broad composite differences can obscure more specific usability concerns.

Existing evidence gives no reason to expect a simple universal pattern. Reviews find generally positive but heterogeneous relationships between children's nature contact and well-being (Arola et al., 2023; Chawla, 2015; Fisher, 2024). A large study of school-aged children in Jersey reported higher nature connectedness among girls, while also showing that age, school location and other contextual factors mattered (Price et al., 2022). Research on school grounds likewise indicates that design and social organisation can shape girls' and boys' access, activity and spatial strategies (Dyment et al., 2009; Saragih & Subroto, 2023). Such findings make sex a useful analytical lens, but not an explanation by itself.

The question is particularly underdeveloped in Sub-Saharan Africa. Emerging biophilic research has largely examined whether nature-responsive qualities are present or beneficial, often in tertiary or purpose-designed settings (Umeora et al., 2025). Ugandan school research has concentrated more heavily on access, educational quality and infrastructure constraints (Asad, 2021; Ngware et al., 2016), even as regional guidance increasingly recognises nature and biodiversity in school design (Feilden Foundation, 2024). Mukono District combines rural, peri-urban and rapidly urbanising conditions (Uganda Bureau of Statistics, 2017), making it possible to explore subgroup variation across contrasting school contexts.

An earlier article from the broader doctoral study examined the overall mixed-methods relationship between perceived biophilic school environments and pupil well-being using the combined pupil sample (Marete, 2025). It did not report sex-disaggregated composites, false-discovery-rate corrections, item-level subgroup patterns or the school- and age-adjusted model presented here. The present paper therefore addresses a distinct inclusive-design question within the same dataset.

The analysis used the recorded binary sex variable because gender identity and gendered social processes were not measured. The terms boys and girls refer only to those recorded categories and do not imply biological causation. The study asked: (1) how similar or different were boys' and girls' composite well-being and environmental-perception scores; (2) did any differences remain after multiple-comparison control; (3) which specific items warranted further design enquiry; and (4) did the ESE contrast persist after age and school adjustment?

INCLUSIVE DESIGN AND SUBGROUP HETEROGENEITY

Biophilic design encompasses direct nature, sensory variability, nature-like spatial configurations and natural analogues (Browning et al., 2014; Kellert, 2018; Ryan et al., 2014). These qualities may support restoration and well-being, but their availability does not guarantee equal experience. A window may provide daylight while seating arrangements affect who benefits from it; a naturalised area may exist while peer occupation or safety concerns influence who uses it; and comfortable furniture may affect participation even though it is not uniquely biophilic. Inclusive assessment must therefore examine both broad environmental domains and specific points of interaction between pupils and space.

This study treats subgroup similarity as substantively informative rather than as an absence of results. Similar composite scores would indicate that the broad domains were not strongly differentiated by recorded sex in this sample. Localised item differences, if they survived multiplicity correction, would identify concrete questions for participatory follow-up. The analytical logic is thus diagnostic and design-oriented, not an attempt to rank one sex as more connected to nature.

METHODS

Design and sample

The study was a secondary analysis of cross-sectional questionnaires from four purposively selected government-sponsored primary schools in Mukono District. Schools A and B were peri-urban, School C urban and School D rural. The item-level workbook contained 302 complete records: 148 boys (49.0%) and 154 girls (51.0%). School distributions were A=23, B=101, C=106 and D=72; ages ranged from 9 to 17 years (M=12.62, SD=1.16). Recorded sex composition varied among schools, making contextual adjustment important.

Table 1. Survey participants by school and recorded sex

School	Context	Boys	Girls	Total	Boys %	Girls %
A	Peri-urban	10	13	23	43.5	56.5
B	Peri-urban	48	53	101	47.5	52.5
C	Urban	58	48	106	54.7	45.3
D	Rural	32	40	72	44.4	55.6
Total	—	148	154	302	49	51

Note. Percentages are calculated within each school. These are questionnaire records and should not be substituted for school-register or examination denominators.

School contributions were highly unequal: School A supplied 7.6% of the analytical sample, compared with 33.4% from School B, 35.1% from School C and 23.8% from School D. Recorded sex was comparatively balanced overall, but the proportion of girls ranged from 45.3% to 56.5% across schools. Pooled subgroup estimates could therefore reflect both pupil-level variation and the composition of the participating schools. School indicators were included in the sensitivity model for this reason; separate school-specific hypothesis tests were not emphasised because some sex-by-school cells were small.

Relationship to the broader study. Questionnaire data were collected within the convergent mixed-methods study reported by Marete (2025). No new participants were introduced. The current paper reports a separate exploratory analysis of subgroup similarity and variation using sex-disaggregated composite scores, multiplicity-controlled item comparisons and school- and age-adjusted sensitivity analysis that were not the focus of the earlier publication.

Measures

The questionnaire used five-point agreement responses. Mean composites represented Emotional and Social Environment (8 items), Nature in the Space (10), Sensory Nature Stimuli (10), Nature of the Space (13) and Natural Analogues (9). Internal consistency was ESE α=.568, NIS α=.715, SNS α=.726, NOS α=.704 and NA α=.718. ESE's modest reliability requires caution and is not repaired by the high alpha for all 50 heterogeneous items combined.

Analysis

Welch independent-samples t tests compared boys and girls for each outcome. For every comparison, the test statistic was calculated from the difference in group means divided by its unequal-variance standard error, and the degrees of freedom were estimated using the Welch-Satterthwaite equation. This specification was selected because school composition and response variability could differ between the two groups; equal variances were therefore not assumed. Two-sided tests were used. Cohen's d was calculated as the girls' mean minus the boys' mean divided by the pooled within-group standard deviation, so positive values indicate higher means among girls. Approximate 95% confidence intervals for d were calculated from its large-sample standard-error.

The five composite-domain comparisons were specified before examining subgroup results because they corresponded to the questionnaire's established scoring structure. The 50 individual-item comparisons were exploratory and were used to locate concrete design questions rather than confirm item-specific hypotheses. Benjamini-Hochberg false-discovery-rate (FDR) adjustment was applied separately within these two families. Raw p values were ordered from smallest to largest, compared with rank-specific thresholds $(i/m)q$ at q=.05, and converted to monotonic adjusted p values. Separating the five prespecified domain tests from the 50 exploratory tests prevented the larger item family from determining the evidential threshold for the primary composite comparisons.

A sensitivity OLS model predicted ESE from recorded sex, continuous age and three school indicator variables, with one school serving as the reference category. School was included because the four sites differed in setting, size and sex composition, while age was included because pupils ranged from 9 to 17 years and age may influence environmental perception and social experience. HC3 heteroskedasticity-consistent standard errors and two-sided 95% confidence intervals were used. The model was intended to assess attenuation after measured contextual adjustment, not to estimate school-independent or causal sex effects. The workbook contained age, recorded sex, school membership and questionnaire responses. It did not contain consistent pupil-level measures of socioeconomic position, disability, seating position, mobility, attendance, peer relations, safety, household context or direct access to particular environmental features; these potentially relevant characteristics could not be adjusted for. Interpretation considered similarity across outcomes, effect magnitude and precision, multiplicity-adjusted evidence and attenuation after contextual adjustment. Isolated raw p values were not treated as findings.

Ethics

Permission was obtained from the Maseno University School of Graduate Studies and the Uganda Christian University Research Ethics Committee (UG-REC-026), together with relevant authorities. Parents or guardians provided informed consent; pupils provided verbal and written assent after receiving age-appropriate information about voluntariness, confidentiality and withdrawal. Schools and participants were anonymised.

RESULTS

Table 2. Domain comparisons by recorded sex

Domain	Boys M (SD)	Girls M (SD)	d	95% CI for d	Raw p	FDR p
ESE	3.77 (0.64)	3.97 (0.61)	0.31	.08–.54	0.008	0.039
NIS	3.55 (0.79)	3.69 (0.69)	0.19	−.04–.42	0.104	0.134
SNS	3.50 (0.78)	3.68 (0.77)	0.23	.00–.46	0.048	0.119
NOS	3.52 (0.66)	3.65 (0.66)	0.19	−.04–.42	0.107	0.134
NA	3.41 (0.81)	3.52 (0.85)	0.14	−.09–.37	0.219	0.219

Note. Welch unequal-variance tests; boys n=148 and girls n=154. Positive d indicates a higher mean among girls. Confidence intervals are approximate two-sided 95% intervals. FDR p controls the five prespecified domain comparisons.

At composite level, similarity was the dominant pattern. Four of the five domains did not show statistically supported differences after FDR correction. ESE was the exception: girls reported a mean .20 points higher than boys (d=.31, 95% CI [.08, .54]; FDR p=.039). The raw SNS contrast met the conventional .05 threshold but did not survive domain-level correction. In the school- and age-adjusted sensitivity model, the coefficient for recorded female sex was B=.140 (95% CI [−.002, .282]; HC3 p=.054). Its interval included zero, and the estimate was smaller than the unadjusted mean difference. This attenuation is consistent with some overlap between the observed contrast and age or school composition, although the available data cannot separate their contributions or establish causation.

Table 3. Item differences surviving FDR correction across 50 tests

Item (abbreviated)	Boys M	Girls M	d	95% CI for d	Raw p	FDR p
ESE Q7: classroom lighting sufficient	3.96	4.34	0.33	.10–.56	0.004	0.041
SNS Q4: bird sounds through windows	3.45	3.93	0.34	.11–.57	0.003	0.04
SNS Q6: smell of flowers	3.33	3.92	0.4	.17–.63	<.001	0.031
NOS Q5: opportunity to explore	3.21	3.71	0.35	.12–.58	0.002	0.04
NA Q6: chair comfort	3.01	3.55	0.36	.13–.59	0.002	0.04

Note. Item wording is abbreviated; boys n=148 and girls n=154. Confidence intervals are approximate two-sided 95% intervals. All retained effects were small. The 50 item comparisons were exploratory and were not preregistered; FDR p controls that exploratory family.

The exploratory item analysis produced a complementary pattern: 45 of 50 comparisons did not survive FDR correction, while five small differences remained. These were distributed across four domains and concerned lighting sufficiency, bird sounds, flower scent, opportunities to explore and chair comfort. The FDR-surviving results should be treated as prioritised signals for follow-up, not as confirmed sex-specific effects. Their diversity does not indicate a general female biophilic preference; instead, it identifies concrete environmental interactions whose meaning may depend on access, seating, mobility, peer relations, comfort and school-specific conditions.

DISCUSSION

Broad similarity is an inclusive-design finding

The clearest and most constructive result was broad similarity. Boys and girls reported comparable perceptions across four of the five composite outcomes after multiplicity control. This supports a shared inclusive-design agenda: schools can improve access to daylight, nature, sensory variety and comfortable space for all pupils without presuming fundamentally different environmental needs by sex. The small ESE contrast warrants further enquiry, but its attenuation and imprecision after age and school adjustment indicate that institutional composition and everyday context may contribute to the observed pattern. The analysis therefore does not attribute the contrast directly to sex.

The result also qualifies international evidence reporting higher nature connectedness among girls (Price et al., 2022). The current questionnaire measured perceptions of particular school-environment qualities rather than a general identity-level connection to nature. Differences between these constructs, as well as cultural and institutional context, may explain why a consistent female advantage was not observed across the four biophilic domains.

Localised differences reveal design questions

The five retained item differences shift attention from abstract sex preference to concrete environmental encounters. Lighting and chair comfort raise questions about seating position, visibility, posture and everyday usability. Bird sounds and flower scent may reflect proximity to windows, time spent in particular areas or opportunities to notice sensory nature. Exploration may depend on mobility, peer relations, confidence, safety and rules governing the use of school space. School-specific conditions may shape all of these encounters. Research showing gendered occupation of school grounds suggests that spatial access can be negotiated socially as well as provided physically (Dyment et al., 2009; Saragih & Subroto, 2023). The present data cannot determine which mechanism operated, but they identify where observation and pupil dialogue can productively begin.

The item pattern also exposes measurement boundaries. Chair comfort sits uneasily within Natural Analogues, and perceived lighting may reflect both physical illumination and seating location. Rather than weakening the paper, these ambiguities show why broad biophilic composites should be refined through cognitive interviewing, environmental measurement and qualitative accounts of how children use classrooms and school grounds.

Implications for inclusive school environments

The practical response is inclusive provision rather than sex-segregated design. Schools should seek adequate daylight across seating positions, comfortable furniture, safe and socially accessible opportunities to explore, and multisensory contact with nature for all pupils. Participatory walkthroughs, pupil mapping and small-group discussions can then test whether particular children use, avoid or value spaces differently and why. This approach converts subgroup statistics into questions for equitable design without turning small average differences into stereotypes.

The findings extend the pooled well-being results reported by Marete (2025). The earlier study demonstrated an overall relationship between biophilic school experience and well-being. The present analysis shows that this general relationship coexists with broad subgroup similarity and a small number of localised differences. Reporting both levels gives designers a more precise basis for action than either pooled averages or a simple claim that girls respond more positively.

STRENGTHS AND LIMITATIONS

Strengths include complete pupil-level records, explicit attention to similarity as well as difference, confidence intervals for effect estimates, separate multiplicity control for prespecified domain and exploratory item analyses, and contextual sensitivity adjustment. The study nevertheless used binary recorded sex and did not measure gender identity, seating position, spatial access, mobility, disability, safety, peer occupation, socioeconomic conditions or other gendered social processes. Data were cross-sectional and self-reported; four schools were purposively selected and contributed highly unequal numbers of pupils; age was heterogeneous; ESE reliability was modest; and item hypotheses were exploratory. School-specific sex-by-domain estimates were not emphasised because several cells were small and the four schools could not support reliable multilevel or school-stratified inference. The adjusted model reduces, but does not remove, contextual confounding. Findings cannot establish causal, biological or universal sex differences.

CONCLUSION

Pooled averages did not tell the whole story, but the evidence also did not support a stable female advantage across biophilic dimensions. Boys and girls reported broadly similar environmental experiences, accompanied by one small composite difference and five exploratory item signals concerning light, sensory nature, exploration and seating comfort. The positive contribution is an inclusive-assessment principle: subgroup analysis can help locate questions about access, comfort and use without prescribing different environments according to sex. Future research should combine validated child-centred measures and objective environmental data with participatory walkthroughs, pupil mapping, observation and small-group discussion to investigate why particular features are experienced differently. Studies spanning larger numbers of schools and following pupils over time are needed to distinguish pupil-level patterns from school conditions and to assess whether observed differences persist or change.

REFERENCES

1. Asad, K. W. (2021). Primary and secondary education in Uganda: Challenges and prospects. Interdisciplinary Journal of Education, 4(1). https://doi.org/10.53449/ije.v4i1.152
2. Arola, T., Aulake, M., Ott, A., Lindholm, M., Kouvonen, P., Virtanen, P., Paloniemi, R., & Shibata, S. (2023). The impacts of nature connectedness on children's well-being: A systematic review. Journal of Environmental Psychology, 85, 101913. https://doi.org/10.1016/j.jenvp.2022.101913
3. Browning, W. D., Ryan, C. O., & Clancy, J. O. (2014). 14 patterns of biophilic design. Terrapin Bright Green.
4. Chawla, L. (2015). Benefits of nature contact for children. Journal of Planning Literature, 30(4), 433–452. https://doi.org/10.1177/0885412215595441
5. Dyment, J. E., Bell, A. C., & Lucas, A. J. (2009). The relationship between school ground design and intensity of physical activity. Children's Geographies, 7(3), 261-276. https://doi.org/10.1080/14733280903024423
6. Fisher, K. (2024). The biophilic school: A critical synthesis of evidence-based systematic literature reviews. Architecture, 4(3), 457–478. https://doi.org/10.3390/architecture4030025
7. Feilden Foundation. (2024). East African Schools Design Guide. Feilden Foundation in partnership with Enabel.
8. Kellert, S. R. (2018). Nature by design: The practice of biophilic design. Yale University Press.
9. Marete, J. N. (2025). The impact of biophilic interior design on pupil well-being in Ugandan primary schools: A convergent mixed-methods study. International Journal of Research and Innovation in Social Science, 9(10), 7961-7967. https://doi.org/10.47772/IJRISS.2025.910000653
10. Ngware, M., Hungi, N., Mahuro, G., Mutisya, M., & Abuya, B. (2016). The quality of education in Uganda: A case of Iganga and Mayuge Districts. African Population and Health Research Center. http://dx.doi.org/10.13140/RG.2.2.18273.92004
11. Price, E., Maguire, S., Firth, C., Lumber, R., Richardson, M., & Young, R. (2022). Factors associated with nature connectedness in school-aged children. Current Research in Ecological and Social Psychology, 3, 100037. https://doi.org/10.1016/j.cresp.2022.100037

12. Ryan, C. O., Browning, W. D., Clancy, J. O., Andrews, S. L., & Kallianpurkar, N. B. (2014). Biophilic design patterns: Emerging nature-based parameters for health and well-being in the built environment. ArchNet-IJAR, 8(2), 62–76.
13. Saragih, J. F. B., & Subroto, T. Y. W. (2023). Child-friendly school: Female students' strategies for equality in accessibility of school playground. Journal of Asian Architecture and Building Engineering, 22(4), 2047-2057. https://doi.org/10.1080/13467581.2022.2153061
14. Uganda Bureau of Statistics. (2017). National Population and Housing Census 2014: Area specific profile series—Mukono District. Uganda Bureau of Statistics.
15. Umeora, C. O., Onwuzuligbo, C. C., & Ononuju, F. I. (2025). The role of biophilic campus design in enhancing university environments in southeast Nigeria. Open Journal of Environmental Research, 6(1), 18–27. https://doi.org/10.52417/ojer.v6i1.858