



Evaluation of Outdoor Seating Areas for Thermal Comfort and Functional Utilization at Caleb University, Imota, Nigeria

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ABSTRACT

This study empirically evaluates the impact of outdoor seating area design on thermal comfort and functional utilization at Caleb University, Imota, Nigeria. The research analyzes the relationship between microclimatic variables—air temperature, relative humidity, and solar radiation—and observed occupancy patterns of students and staff. Using a qualitative-dominant mixed method incorporating Post-Occupancy Evaluation (POE) and behavioral mapping with a 100-student survey, the study captures lived experiences of campus users. Findings reveal a severe design-climate mismatch: 82% of respondents report thermal discomfort (hot to unbearably hot) during peak solar hours (12 PM–3 PM), leading to 88% thermal displacement into indoor corridors. Concrete heat absorption and absence of natural shade are the primary complaints (72% of students). The study justifies a transition toward biophilic and bioclimatic design, providing a roadmap for thermally viable campus landscapes that support academic focus and social cohesion throughout the day.

Keywords: Biophilic design, Behavioral mapping, Campus microclimate, Outdoor thermal comfort, Post-Occupancy Evaluation, Tropical heat island

INTRODUCTION

1 Background and Context

The external environment of a university campus operates as a vital "third space" mediating between formal education in lecture halls and private life in student accommodations (Dixon & Montgomery, 2017). Courtyards, plazas, and shaded seating areas foster social cohesion, psychological well-being, and scholarly interaction. In tropical climates like Imota, Lagos (6.65° N, 3.68° E), high solar radiation and relative humidity (>80%) severely challenge outdoor habitability. Without adequate shading and ventilation, designated social spaces become "dead zones" that users actively avoid during daylight hours.

The relationship between environmental quality and user engagement has been empirically established in Nigerian educational contexts. Ademakinwa et al. (2024) demonstrated that environmental stress directly reduces user satisfaction and job performance at Caleb University, a principle equally applicable to outdoor seating areas. Furthermore, Adeyemi et al. (2025) found that spatial adaptability in learning environments directly enhances user satisfaction in Nigerian educational settings, suggesting that inflexible, thermally uncomfortable outdoor spaces similarly fail to meet user needs.

Problem Statement

Despite Caleb University's master-planned design, outdoor seating areas are severely underutilized between 10:00 AM and 4:00 PM. Intense solar radiation and humidity create localized heat traps, forcing students to migrate to crowded cafeterias and corridors, thereby fragmenting campus social life. Many seating zones prioritize aesthetic symmetry over thermal functionality, incorporating high-heat-retention materials (concrete, metal) and lacking wind-channeling vegetation or adequate shading structures. This design-climate mismatch represents a failure of bioclimatic design principles, resulting in underutilized capital investments and diminished campus vitality.

Research Aim and Objectives

Aim: To evaluate existing outdoor seating facilities at Caleb University regarding thermal comfort and functional efficiency, using user-experience data to propose bioclimatic redesign strategies.

Specific Objectives are to:

- i) assess the physical configuration, material composition, and shading efficacy of existing outdoor seating areas;
- ii) investigate student perceptions of thermal comfort and identify functional requirements for outdoor seating and
- iii) map behavioral migration patterns in response to microclimatic stressors during peak solar hours.

Research Gap

While general literature exists on tropical thermal comfort and Urban Heat Island effects in Nigeria, localized qualitative user-experience data within private universities is scarce. Most existing studies rely on simulated microclimatic models rather than lived user experiences. This study bridges that gap using Post-Occupancy Evaluation (POE) and behavioral mapping, prioritizing empirical user feedback over generalized climatic assumptions.

LITERATURE REVIEW

Conceptual Framework

Outdoor Thermal Comfort (OTC)

Outdoor Thermal Comfort is determined by the interaction of four primary environmental variables: air temperature, solar radiation, wind speed, and relative humidity (Nikolopoulou & Lykoudis, 2006). In Nigeria's humid tropical climate, solar radiation and humidity emerge as the dominant stressors, with unshaded surfaces elevating localized temperatures by 3–5°C above regional means (Omonijo et al., 2014). Thermal comfort is not merely a physiological condition but a psychological one: when users experience discomfort, their willingness to linger, study, or socialize outdoors diminishes significantly.

Ergonomics and Functional Use

The material composition of seating directly affects thermal experience. Concrete and metal benches absorb solar radiation throughout the day and re-radiate heat long after sunset, rendering them unusable for extended periods (Adebayo, 2020). Beyond thermal properties, proxemics (Hall, 1966) also matters: seating spaces lacking psychological enclosure—defined by partial walls, vegetation, or overhead elements—are abandoned regardless of thermal state because users feel exposed and uncomfortable.

Urban Microclimates and Campus Design

University campuses generate distinctive microclimates, including "wind canyons" between buildings and "heat pockets" in unshaded courtyards. Abdelaal (2019) introduced "lingering time" as a behavioral indicator of restorative quality: spaces that support extended occupancy are those that successfully mitigate thermal stressors through design interventions.

Theoretical Framework

Adaptive Thermal Comfort Theory

Adaptive Thermal Comfort Theory (Charles, 2003) posits that users actively adapt their behavior when discomfort occurs—seeking shade, adjusting clothing, or moving to alternative locations. In outdoor seating areas, the absence of adaptive options (movable seating, shade structures, breeze access) forces complete abandonment rather than behavioral adjustment. This study applies this framework to understand why students thermally displace rather than adapt in place.

Placemaking and Environmental Psychology

Placemaking theory (Dixon & Montgomery, 2017) requires outdoor seating to function as genuine "places" of belonging, not mere furniture arrangements. Successful placemaking integrates thermal comfort, social affordances, and psychological safety. When thermal conditions fail, the placemaking potential is nullified regardless of aesthetic quality.

Empirical Studies Synthesis

Table 2.1: Summary of Key Empirical Studies

Author(s)	Focus	Key Finding
Nikolopoulou & Lykoudis (2006)	Outdoor thermal comfort	Psychological adaptation allows higher heat tolerance when users perceive control
Omonijo et al. (2014)	Thermal comfort in SW Nigeria	Unshaded surfaces elevate temperatures 3–5°C above regional mean
Adebayo (2020)	Campus courtyards	Poor building orientation stifles natural ventilation
Adeyemi et al. (2025)	Adaptable learning spaces	Spatial adaptability directly enhances user satisfaction in Nigerian educational environments

RESEARCH METHOD

Research Design

A qualitative-dominant mixed method was adopted, incorporating Post-Occupancy Evaluation (POE), structured surveys, and behavioral mapping. This design prioritizes lived user experience while allowing for quantitative triangulation of occupancy patterns and thermal perception.

Study Area

The study was conducted at Caleb University Main Campus, Imota, Lagos. High-traffic zones near the College of Environmental Sciences and the central cafeteria were selected as observation sites, as these areas receive the highest pedestrian volume and contain the majority of designated outdoor seating.

Target Population and Sampling

The target population comprised undergraduate students who regularly use or have access to campus outdoor seating areas. A purposive sample of 100 students was selected to ensure representation across academic years and usage patterns. Surveys were administered during peak solar hours (12 PM–3 PM) to capture "right-now" comfort votes rather than retrospective recall, thereby minimizing memory bias.

Data Collection Instruments

Questionnaires: A structured questionnaire captured: (i) demographic and usage pattern data; (ii) a 7-point thermal sensation scale (from "very cool" to "unbearably hot"); (iii) material complaints; and (iv) requested design features.

Behavioral Mapping: Real-time user density was recorded at 30-minute intervals between 8 AM and 6 PM across four observation days. Mapping recorded the number of users, their activities (socializing, studying, waiting, eating), and their precise locations relative to shade and seating types.

Data Analysis

Quantitative survey data were analyzed using descriptive statistics (frequencies, percentages, mean scores). Behavioral mapping data were analyzed spatially to correlate occupancy patterns with solar exposure trajectories and material types. Qualitative open-ended responses were analyzed thematically to identify recurring complaints and suggestions.

RESULTS AND DISCUSSION

Demographic and Usage Patterns

Table 4.1: Survey Responses (N=100)

Category	Response	n (%)
Primary Intent	Socializing	58
	Studying	22
	Waiting	15
	Eating	5
Peak Usage Time	Morning (8–11 AM)	45
	Afternoon (12–3 PM)	12
	Evening (4–6 PM)	43
Thermal Sensation (Peak Hours)	Hot/Very hot	67
	Unbearably hot	15
	Neutral/slightly warm	18
	Cool	0
Material Complaint	Concrete	72
	Metal	20
	Wood/plastic	8
Requested Feature	Natural shade (trees)	40
	Artificial shade (sails/pergolas)	35
	Charging ports/Wi-Fi	15
	Better ergonomics	10

Interpretation: Table 4.1 reveals that while 58% of students use outdoor spaces for socializing, only 12% use them during peak afternoon hours (12 PM–3 PM), compared to 45% in the morning and 43% in the evening. This diurnal pattern strongly suggests that thermal conditions, not lack of interest, drive avoidance behavior.

Microclimatic Perception

Table 4.2: Thermal Sensation Distribution During Peak Hours (12–3 PM)

Thermal Sensation	Percentage
Unbearably hot	15%
Very hot	42%
Hot	25%
Slightly warm	12%
Neutral	6%
Slightly cool	0%
Cool	0%

A combined 82% of respondents reported "hot" to "unbearably hot" during peak hours, with zero respondents reporting "cool" sensations. This finding aligns with Omonijo et al. (2014), who demonstrated that unshaded surfaces in South-Western Nigeria elevate localized temperatures by 3–5°C above regional means. The high sky-view factor in most seating areas (minimal overhead shade) combined with relative humidity exceeding 80% blocks evaporative cooling, creating a sustained heat stress environment.

Behavioral Mapping and Migration

Table 4.3: Occupancy by Time Period and Location Type

Time Period	Outdoor Seated Occupancy (avg. users/zone)	Indoor Corridor Occupancy (avg. users/zone)	Thermal Displacement Rate
8–11 AM	28	12	30%
12–3 PM	8	58	88%
4–6 PM	32	18	36%

Interpretation: Behavioral mapping revealed that 88% of students thermally displace indoors during peak solar hours (12–3 PM), migrating to crowded cafeterias and corridors. Migration paths align exactly with solar exposure trajectories: users follow shade lines throughout the day, abandoning seating zones once direct sunlight reaches the benches. This finding confirms the Adaptive Thermal Comfort Theory prediction: when adaptive options within the space are absent, users abandon the space entirely rather than adjusting behavior in place.

Material Performance

Table 4.4: Material-Related Complaints

Material	Percentage of Complaints	Primary Issue Cited
Concrete	72%	Absorbs heat, stays hot for hours
Metal	20%	Burns skin on contact
Wood/Plastic	8%	Less problematic but still hot

Concrete benches received the highest complaint rate (72%). Concrete's high thermal mass absorbs solar radiation throughout the day and re-emits heat long after sunset, rendering benches unusable from late morning until evening. Qualitative responses captured this phenomenon:

"I only sit outside before 10 AM. After that, the concrete is hot until sunset." – Respondent 34

"No breeze reaches the courtyard. We chase tiny slivers of shade." – Respondent 67

"We have nowhere to sit outside after 11 AM except the cafeteria, which is always overcrowded." – Respondent 12

Discussion

The findings reveal a severe design-climate mismatch at Caleb University. The 82% thermal discomfort rate and 88% thermal displacement rate indicate that existing outdoor seating areas fail to meet basic habitability standards during peak usage hours. This aligns with Ademakinwa et al. (2024), who demonstrated that environmental stress directly reduces user engagement in Caleb University settings. The concrete-heavy material palette, absence of natural shade from broad-canopy trees, and poor wind-channeling orientation collectively create localized heat traps that users rationally avoid. Comparing these findings to Adeyemi et al. (2025), who demonstrated that spatial adaptability enhances user satisfaction in Nigerian educational environments, the rigidity of existing outdoor seating—fixed orientation, fixed materials, no adaptive features—directly contradicts the adaptability principle. Users cannot move seats into shade, cannot adjust orientation toward breeze, and cannot modify their environment to improve comfort. This design inflexibility is the primary driver of the 88% displacement rate.

From a theoretical perspective, the findings validate Adaptive Thermal Comfort Theory (Charles, 2003): when users lack behavioral adaptation options within a space (movable seating, adjustable shade, breeze access), they abandon the space entirely rather than adapting in place. The 88% displacement rate represents a complete failure of behavioral adaptation within the seating zones themselves. Furthermore, Placemaking theory (Dixon & Montgomery, 2017) holds that successful public spaces must offer thermal refuge to function as genuine "places" of belonging. At Caleb University, the absence of thermal refuge nullifies any placemaking potential, reducing outdoor seating to symbolic gestures rather than functional environments. Compared to findings from similar tropical campus contexts—where Omonijo et al. (2014) reported unshaded surfaces elevate temperatures by 3–5°C above regional means—the Caleb University case is not unique but represents a predictable outcome of ignoring bioclimatic design principles. The path forward requires a deliberate shift from aesthetic-driven design to performance-based, user-centered bioclimatic strategies.

Summary of Findings

Table 5.1: Summary of Key Findings

Finding	Percentage	Implication
Thermal discomfort during peak hours	82%	Spaces are uninhabitable during midday
Thermal displacement indoors	88%	Students abandon outdoor spaces entirely
Concrete as primary complaint	72%	Material selection is a design failure
Peak usage shift to morning/evening	88% reduction at midday	Design does not match tropical climate

CONCLUSION

Empty outdoor seating areas at Caleb University reflect architectural failure, not student disinterest. Students actively desire outdoor spaces for socializing (58%) and studying (22%), but thermal conditions force them indoors. The concrete-heavy material palette, absence of natural shade, and poor

wind-channeling design create localized heat traps that are unusable for approximately six hours daily (10 AM–4 PM). Bioclimatic redesign can transform these dead zones into vibrant, thermally viable hubs that support academic focus and social cohesion throughout the day.

RECOMMENDATIONS

Table 5.2: Recommendations by Timeline

Timeline	Intervention	Rationale	Estimated Impact
Short-term (0–6 months)	Install shade sails over concrete benches	Immediate reduction in direct solar radiation	40–50% reduction in surface temperature
	Add portable fans in key courtyards	Enhance air movement for evaporative cooling	10–15% improvement in perceived comfort
Long-term (6–24 months)	Replace concrete/metal with Timber-Plastic Composites (TPC)	Low thermal mass, does not retain heat	60–70% reduction in surface temperature
	Install perforated pavilions with stack-effect ventilation	Passive cooling through natural airflow	25–30% improvement in thermal comfort
	Plant broad-canopy trees on south and west orientations	Natural shade aligned with solar trajectory	3–5°C reduction in ambient temperature
	Integrate solar charging ports and Wi-Fi nodes	Increase functional utility and dwell time	30–40% increase in afternoon occupancy

Limitations

This study was conducted exclusively during the dry season (November–February). During the rainy season (April–October), high humidity and rainfall may introduce different comfort challenges, including waterlogging, mosquito activity, and reduced evaporative cooling. Future research should examine wet-season conditions and include objective microclimatic measurements (temperature/humidity data loggers, anemometers) to validate self-reported perceptions.

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