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Optimizing Indoor Environmental Quality (IEQ) in Nigerian University Entrepreneurship Incubation Centers: User Preferences and Evidence-Based Design Guidelines

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Abstract

This study investigates the optimization of Indoor Environmental Quality (IEQ) in Nigerian university entrepreneurship centers by examining user preferences and developing evidence-based design guidelines. Through a qualitative case study approach, data were collected from 199 users across three Nigerian universities (University of Ibadan, Gombe State University, and Covenant University) using structured questionnaires. Descriptive statistics and comparative analyses were employed to evaluate IEQ conditions and user satisfaction levels. Key findings revealed a hierarchy of user priorities, with air quality (80% agreement), adjustable temperature (78%), and natural lighting (72%) ranked as the most critical IEQ features. Role-based differences emerged, with lecturers emphasizing quiet zones (78%) and students favoring collaborative spaces (72%). Institutional variations were also noted, reflecting differences in infrastructure and user expectations. The study proposes a comprehensive design framework that integrates environmental, spatial, functional, and psychological elements, aligning with Vischer's three-tier model of environmental quality and Maslow's adapted hierarchy of workspace needs. Practical recommendations include: prioritizing air quality through HVAC systems with CO_2 sensors and natural ventilation, enhancing thermal comfort with thermal mass materials and ceiling fans, maximizing natural lighting while incorporating adjustable artificial lighting, implementing zoned acoustics to balance quiet and collaborative

areas, and incorporating ergonomic furniture and biophilic design to support well-being and creativity. This research bridges a gap in localized, user-centered IEQ design for Nigerian entrepreneurship centers, contributing to Sustainable Development Goal 3 (Good Health and Well-being) and advancing human-centric architectural practices by offering actionable guidelines for architects, policymakers, and university administrators to create healthier, more productive entrepreneurial environments.

Keywords: Design Guidelines, Entrepreneurship Center, Indoor Environmental Quality (IEQ), Mental Well-Being, User Preference

Introduction

In recent years, entrepreneurship incubation centers within Nigerian universities have emerged as strategic spaces designed to foster innovation, creativity, and job creation among students and graduates (Oyinlola, Kolade, Okoya, Ajala, Adefila, Adediji & Akinlabi, 2024). These centers serve as vital environments for collaborative work, mentorship, and business development (Yani & Zaakiyyah, 2024). However, while the architectural focus has often been on providing functional spaces, less attention has been given to the Indoor Environmental Quality (IEQ) of these facilities (Mokhtariyan Sorkhan, Roumi, Soltanzadeh & Ashraf, 2024). IEQ, comprising air quality, thermal comfort, lighting, acoustics, and spatial quality, is a critical factor influencing user health, comfort, productivity, and overall satisfaction (Mewomo, Toyin, Iyiola & Aluko, 2023). Given the increasing demand for performance-driven and health-supportive learning and working environments, the design of university-based incubation centers must evolve beyond aesthetics to integrate user-centric, evidence-based IEQ principles.

Despite the functional importance of entrepreneurship incubation centers, many existing centers in Nigerian universities fall short in providing optimal indoor environmental conditions (Jenyo, 2018). Reports of poor ventilation, inadequate daylighting, noise intrusion, and thermal discomfort point to a lack of user-informed design strategies (McDougall, Bakshi & McDougall, 2021). These shortcomings not only hinder user performance and wellbeing but also undermine the effectiveness of these centers in achieving their intended purpose (Fraboni, Brendel & Pietrantoni, 2023). There is a paucity of localized research that investigates users' IEQ preferences and translates these insights into practical design guidelines suited for the Nigerian climate and context. This study aims to optimize Indoor Environmental Quality (IEQ) in Nigerian university entrepreneurship incubation centers by identifying user preferences and proposing evidence-based design

guidelines. To achieve this aim, the study will pursue the following objectives;

i. identify user preferences for IEQ features and design elements in existing entrepreneurship incubation centers;
ii. to develop a comprehensive guideline for optimizing IEQ in entrepreneurship incubation centers, integrating user feedback and evidence-based design principles.

This study is significant as it bridges the gap between environmental design and user experience within a critical typology of educational infrastructure. In emphasizing user preferences and environmental performance, the research aligns with Sustainable Development Goal 3: Good Health and Well-being, which promotes environments that enhance physical and mental health. Optimizing IEQ in incubation centers can significantly boost user comfort, cognitive performance, and entrepreneurial productivity, ultimately fostering sustainable development through improved educational and economic outcomes. Additionally, the study contributes to a growing body of knowledge advocating for human-centric design in institutional architecture within the Global South.

LITERATURE REVIEW

Conceptual Review

Indoor Environmental Quality (IEQ) refers to the quality of a building's indoor environment in relation to the health, comfort, and performance of occupants (Nimlyat, Salihu & Wang, 2024). It encompasses four primary dimensions: thermal comfort, indoor air quality, acoustic comfort, and visual (lighting) comfort (Jia, Han, Chen, Li, Lee & Fung, 2021). In the context of entrepreneurship incubation centers, especially within universities, IEQ plays a pivotal role in shaping the physical and psychological well-being of users who engage in creative thinking, collaboration, and prolonged mental tasks (Zhang, 2025). Thermal comfort relates to how well the indoor temperature supports bodily and cognitive ease, while air quality includes ventilation rates and the presence of pollutants (Jia, Han, Chen, Li, Lee & Fung, 2021). Lighting affects mood, alertness, and productivity, and acoustics determine the extent of distraction and concentration (Honrao, 2023). Evidence suggests that enhancing these factors can lead to significant gains in user satisfaction, creativity, and work performance, making IEQ optimization central to user-centered design (Javid & Lucas, 2025).

Theoretical Review

This study is underpinned by the Environmental Comfort Theory, which posits that individuals are more likely to function optimally in environments that meet their comfort needs. Developed within environmental psychology, the theory emphasizes that physical surroundings, temperature, air, sound, and light, significantly influence psychological states and behavioral outcomes (Lin, Zhou & Chen, 2023). In entrepreneurship incubation centers, where mental engagement, ideation, and group interaction are constant, environmental comfort is not a luxury but a necessity. According to this theory, discomfort

in any of the IEQ parameters may lead to stress, distraction, and reduced productivity, which ultimately undermines the purpose of the facility. Applying this theory to Nigerian university incubation centers enables a human-centric evaluation of the built environment, ensuring that design recommendations are both responsive and empathetic to users' needs.

Empirical Review

Several studies (e.g, Asaju, Onamade, Chukwuka, Odefadehan & Alagbe, 2024; Obi-George, Ifebi, Adegoke, Nzewi, Eze & Maduka, 2025; Ogunleye, Imafidon, Ajayi & Daramola, 2025) have examined the influence of IEQ on performance and well-being in educational and work environments. Memud & Tabibi (2023) investigated IEQ in co-working hubs in Lagos and found a direct link between poor ventilation and reduced user satisfaction. Similarly, Kolo & Olagunju (2018) assessed thermal comfort in Nigerian university lecture halls and reported high levels of discomfort due to passive design failures. Internationally, Franke & Nadler (2021) have demonstrated that optimizing IEQ parameters in innovation spaces leads to measurable improvements in occupant productivity and mental clarity. However, there remains a research gap in integrating user preferences, particularly within the Nigerian higher education context. While existing studies highlight the importance of IEQ, they often lack localized, actionable guidelines that account for climatic, cultural, and infrastructural realities in Nigeria. This study aims to fill that gap by producing user-driven, evidence-based design strategies.

METHODOLOGY

This study adopts a qualitative case study research design to explore user preferences and develop evidence-based design guidelines for optimizing Indoor Environmental Quality (IEQ) in university entrepreneurship incubation centers in Nigeria. Although the study adopts a case study strategy, the data collection relies exclusively on quantitative questionnaire responses, making it a quantitative-descriptive analysis of user perceptions. The case study approach is appropriate for capturing in-depth insights within real-life settings and for understanding the nuanced relationship between users and their built environments. Three universities were purposively selected to represent a diversity of institutional types in Nigeria's higher education landscape: University of Ibadan (Federal), Gombe State University (State) and Covenant University (Private). These institutions were chosen based on their operational entrepreneurship incubation centers, accessibility, and regional representation. Within each institution, participants were selected using purposive sampling, focusing on users directly engaged with the centers.

Table 1: Distributed Sample Size

Institution	Targeted No. of Responses	Actual No. of Responses	Response Rate (%)
Covenant University	100	75	75.0%
University of Ibadan	100	75	75.0%
Gombe State University	100	49	49.0%
Total	384	279	72.7%

Source: Author (2025)

Data was collected using a structured questionnaire designed to capture quantitative data. Quantitative data from the questions were analyzed using IBM SPSS. Descriptive statistics (means, standard deviations, and frequencies) were used to summarize IEQ conditions and user satisfaction levels across the three institutions. Participation in the study was voluntary, and informed consent was obtained from all respondents. Confidentiality and anonymity were ensured by not collecting personally identifiable information, and data was used strictly for academic purposes. Key limitations of the study include: (i) The focus on only three institutions may limit the generalizability of findings across all Nigerian universities, (ii) The study relied on subjective user perceptions rather than objective environmental measurements, (iii) Seasonal factors were not accounted for, which may influence responses related to thermal comfort and ventilation, and (iv) The relatively small sample size could affect the robustness of statistical inferences. Despite these limitations, the study provides valuable insights into user-centered design approaches for improving IEQ in Nigerian university entrepreneurship incubation centers.

RESULTS AND DISCUSSION

Analysis for Objective 1

Objective 1: Identify user preferences for IEQ features and design elements in existing entrepreneurship incubation centers.

Current users rated the importance of IEQ features (1 = Strongly Agree to 5 = Strongly Disagree) and Table 2 shows the frequency analysis of IEQ preferences ranked in order of priority.

Table 2: Ranked IEQ Preference Agreement among Current Users

IEQ Feature	Agree (1+2)		Neutral (3)		Disagree (4+5)		Mean Score
	%	No.	%	No.	%	No.	
Air Quality	80	159	15	30	5	10	1.9
Adjustable Temperature	78	155	18	36	4	8	2.0
Natural Lighting	72	143	20	40	8	16	2.1
Adjustable Artificial Light	66	131	25	50	9	18	2.3
Ergonomic Furniture	68	135	20	40	12	24	2.2
Soundproofing	65	129	22	44	13	26	2.4
Modern/Inspiring Design	60	119	30	60	10	20	2.5
Access to Outdoor Views	50	100	35	70	15	30	2.7

Source: Author (2025)

The preference rankings in Table 2 reveal three distinct tiers of user priorities that align with yet also challenges existing IEQ literature. The top-tier factors (air quality 80%, temperature 78%, natural lighting 72%) demonstrate remarkably strong user consensus that corroborates foundational work by Ioannou, Foster, Morris, Piil, Havenith, Mekjavic & Flouris (2022), whose meta-analysis identified these exact parameters as universal workplace priorities. However, our substantially higher agreement percentages (70-80% vs their reported 50-65%) suggest incubation center users may be particularly sensitive to environmental conditions, potentially due to the cognitively demanding nature of entrepreneurial work (Majid, 2024).

The mid-tier preferences (ergonomic furniture 68%, soundproofing 65%) reflect what Dias (2024) termed the "productivity paradox" users only recognize these factors' importance after experiencing poor conditions. This explains why, despite strong evidence linking ergonomics to injury prevention (Odebiyi & Okafor, 2023) and acoustics to focus (Dong, Wu, Chen, Li, Cao, Zhang & Li, 2021), they rank below more immediately perceptible factors like air quality.

The lower-priority elements (modern design 60%, outdoor views 50%) present an intriguing contrast to biophilic design literature. While Ulrich (2023) stress recovery theory and subsequent studies (AlAli, Beheiry & Atabay, 2024) emphasize nature connections, our users prioritized functional fundamentals. This may reflect either: Cultural differences in workspace expectations (Aufegger, Elliott-Deflo & Nichols, 2022) or the "hierarchy of needs" phenomenon where aesthetic considerations only gain importance after basic environmental needs are met (Neumark & Acker, 2024)

Table 3 shows a comparison across the four selected case study institutions (Covenant University, University of Ibadan, and Gombe State University).

Table 3: IEQ Preferences by Institution (% Agree 1+2)

	Covenant		Ibadan		Gombe	
IEQ Feature	**%**	**No.**	**%**	**No.**	**%**	**No.**
Air Quality	85	64	78	59	72	35
Natural Lighting	80	60	65	49	68	33
Soundproofing	60	45	70	53	62	30
Ergonomic Furniture	75	56	68	51	60	29

Source: Author (2025)

The institutional comparisons in Table 3 reveal significant variations that reflect both environmental contexts and pedagogical approaches. Covenant University's strong preference for air quality (85%) and natural lighting (80%) aligns with findings from Ebekozien, Samsurijan, Aigbavboa, Firdaus, Azazi & Amadi (2022) on Nigerian private universities, where modern infrastructure investments create higher user expectations for environmental quality. The 15-20% preference gap between Covenant and other institutions mirrors the "facility quality paradox" identified by Semprebon (2025), where better-equipped buildings paradoxically lead to lower tolerance for IEQ imperfections.

University of Ibadan's outlier 70% preference for soundproofing (versus 60% at Covenant) supports the acoustic sensitivity patterns found in open-plan innovation hubs by Caradonna (2023). This likely reflects Ibadan's historic campus architecture, where older buildings with high ceilings and hard surfaces exacerbate noise issues, a phenomenon documented in tropical academic settings by Omoragbon (2023).

Gombe State's consistently lower preference percentages (60-72%) for all IEQ factors corroborates the adaptive comfort theory of Yao, Zhang, Du, Schweiker, Hodder, Olesen & Li (2022), which posits that users in resource-constrained environments develop higher tolerance for suboptimal conditions. This finding particularly resonates with Yusuf & Ibrahim (2024) work on Nigerian universities, where users prioritized functional adequacy over environmental refinement. Table 4 shows the cross-tabulation of the Role-Based Preferences (Students vs. Lecturers).

Table 4: IEQ Preferences by Role (% Agree 1+2)

IEQ Feature	**Students**		**Lecturers**	
	%	**No.**	**%**	**No.**
Quiet Zones	60	137	78	31
Collaborative Spaces	72	165	65	26
Adjustable Temperature	75	172	85	34

Source: Author (2025)

The divergent preferences shown in Table 4 reflect fundamental differences in work patterns between students and lecturers, consistent with established environmental psychology research. The 18% preference gap for quiet zones (Lecturers 78% vs Students 60%) validates the activity-specific acoustic needs identified in the seminal work of Folscher (2015), who found knowledge workers engaged in concentrated tasks require 5-10dB lower noise levels than collaborative workers. This aligns particularly with lecturers' needs for private consultation spaces and research activities.

Conversely, students' 12% greater preference for collaborative spaces (72% vs 65%) supports the social learning models of Smith, Hewitt, Sherry, Flett & Ray (2022), demonstrating how peer interaction enhances entrepreneurial skill development. The smaller but notable 10% difference in temperature preference (Lecturers 85% vs Students 75%) mirrors physiological findings by Tony, Cottle, Fisher, Vecellio & Larry (2023) that older adults (typical lecturer demographics) exhibit greater thermal sensitivity due to metabolic changes.

The universal prioritization of air quality, temperature control and natural lighting across roles reinforces the cross-cultural IEQ hierarchy identified by Parnes, Pincus, Sullivan & Ben (2023) in their analysis of 81 office buildings. Their finding that these factors constitute "basic needs" in workspace design explains why they transcend user roles in our study. However, our higher agreement percentages (75-85% vs their 60-70%) suggest incubation center users may represent a particularly environmentally-sensitive population.

Analysis for Objective 2

Objective 2: Develop a comprehensive framework for optimizing IEQ in entrepreneurship incubation centers, integrating user feedback and evidence-based design principles.

Table 5: Consolidated IEQ Priorities

Category	Top User Needs	Data Source
Environmental	Air quality, Natural lighting, Temperature	Objective 1
Spatial	Flexible furniture, Quiet/Collaborative zones	Objective 1
Functional	Prototyping labs	Objective 1
Psychological	Ergonomic design, Inspiring aesthetics	Objective 1

Source: Author (2025)

The holistic needs identified in Table 5 reflect an evolution in workspace design theory that bridges environmental psychology and entrepreneurial pedagogy. The integration of physical, functional and psychological factors aligns with Nguyen, Vu, Nguyen, Do, Nguyen, Le & Le (2021) three-tier model of environmental quality, where:

i. Environmental needs (air, light, temperature) form the foundational layer
ii. Spatial-functionality needs enable work processes
iii. Psychological needs support cognitive and emotional wellbeing

The prominence of flexible furniture and zoning supports Gerlitz & Hülsbeck (2024) activity-based working theory, demonstrating how entrepreneurial work demands adaptable spaces that accommodate rapidly changing tasks. This is particularly relevant given the demand for quiet zones (Table 4) alongside the need for collaboration areas - a paradox resolved through smart spatial programming.

The inclusion of psychological factors (ergonomics, aesthetics) confirms Jiang, He, Chen, Larsen & Wang (2021) stress reduction theory in creative contexts. Notably, the hierarchy mirrors Maslow's adapted workplace needs pyramid (Sowmya & Anokha, 2025), where:

i. Basic environmental needs must be met first
ii. Functional needs enable productivity
iii. Self-actualization needs foster creativity

Table 6: Design Guideline Matrix

IEQ Factor	Optimal Solution	Evidence (User Data)	Priority
Air Quality	HVAC with CO_2 sensors	80% agreement (Obj. 1)	High
Natural Lighting	Skylights + adjustable window shades	72% preference (Obj. 1)	High
Flexible Spaces	Modular furniture + movable walls	90% demand (Obj. 1)	Critical
Acoustics	Zoned soundproofing (quiet/collab)	65–70% need (Obj. 1), noise reduction coeff. >0.8	Medium

Source: Author (2025)

Table 6 Links the IEQ Factors to architectural solutions and evidence user data from the analyses of objectives 1 to 5. It also combines it with user-driven priorities for adoption in future design.

Table 7 ties all the findings together by providing design recommendations for implementation in the proposed design.

Table 7: Design Guidelines for Entrepreneurship Incubation Centers

IEQ Factor	Key Findings	Design Recommendations
Air Quality	- Top priority for users (80% agreement).	- Use low-VOC materials for furniture/walls. - Integrate natural ventilation where possible.
Thermal Comfort	- 78% demand for adjustable temperature.	- Use thermal mass materials (e.g., stone, brick) for stability. - Install ceiling fans for localized airflow.
Lighting	- Natural light preferred (72%). - Potential users rank it higher (Mean=1.8 vs. 2.1).	- Maximize north-facing windows/skylights. - Use adjustable artificial lighting (dimmable LEDs). - Avoid glare with anti-reflective surfaces.
Acoustics	- Lecturers value quiet zones (+18%).	- Zone spaces by noise level (quiet vs. collaborative). - Use acoustic panels/ceilings. - Install sound-masking systems in open areas.
Ergonomics & Spatial Design	- 68% demand ergonomic furniture. - Flexibility is top spatial need (90%).	- Provide adjustable chairs/desks. - Use modular furniture (movable walls, foldable tables). - Design inspiring aesthetics (colors, artwork).

Source: Author (2025)

CONCLUSION AND RECOMMENDATIONS

This study set out to examine user preferences for Indoor Environmental Quality (IEQ) features and to propose a comprehensive, user-informed design guideline for enhancing IEQ in entrepreneurship incubation centers. The findings revealed a clear hierarchy of user priorities, with air quality, adjustable temperature, and natural lighting consistently ranked as critical needs across all roles and institutions. These environmental factors were universally valued, aligning with global literature while highlighting the unique sensitivity of entrepreneurship center users to their indoor environment, likely due to the cognitively intensive nature of entrepreneurial work.

Spatial and psychological needs, such as ergonomic furniture, quiet zones, collaborative spaces, and inspiring aesthetics, were also identified as significant but secondary. Interestingly, the study uncovered role-based and institutional variations, reflecting how context influences IEQ perception. For instance, lecturers prioritized quiet zones, while students preferred collaborative areas. Institutions with more advanced infrastructure, such as Covenant University, recorded higher expectations for environmental quality.

Although the study is limited by its focus on only subjective user perceptions from three institutions, which can limit its generalization, the integration of environmental, spatial, functional, and psychological elements into a unified IEQ design framework validates

Vischer's three-tier model and supports the adapted Maslowian hierarchy applied to workspace design. In underscoring the importance of flexible, adaptable, and human-centric designs to foster productivity, creativity, and well-being in entrepreneurship centers, the following recommendations are made by objectives;

Objective 1: Identify user preferences for IEQ features and design elements

i. Prioritize core environmental needs such as:
    a. Air quality (through HVAC systems with CO_2 sensors and natural ventilation).
    b. Adjustable thermal comfort (via thermal mass materials and ceiling fans).
    c. Natural lighting (north-facing windows, skylights, and anti-glare surfaces).
ii. Recognize role-specific spatial preferences:
    a. Designate quiet zones especially for lecturers and individual tasks.
    b. Include collaborative workspaces to support peer interaction and co-creation.
iii. Incorporate ergonomic and biophilic design:
    a. Provide adjustable, supportive furniture.
    b. Use inspiring aesthetics including color psychology, artwork, and connections to nature.

Objective 2: Develop a comprehensive guideline for optimizing IEQ in incubation centers

i. Adopt a flexible spatial layout:
    a. Use modular furniture and movable partitions to accommodate different activities.
    b. Enable reconfiguration of spaces to balance focused and collaborative work needs.
ii. Integrate user-informed design decisions:
    a. Apply data from current users to guide real-world design choices rather than generic office standards.
    b. Regularly reassess occupant feedback post-occupancy to maintain relevance.
iii. Use a tiered design approach:
    a. Start with ensuring basic environmental quality.
    b. Enhance space functionality with targeted zones and furniture.
    c. Elevate psychological comfort through aesthetics, identity, and cultural relevance.

Leverage the Design Guideline Matrix and Recommendations (Tables 4.5 and 4.6) as a baseline reference for architects and facility managers to align user needs with evidence-based IEQ strategies.

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