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Green Campus: Evaluating the Role of Indoor Environmental Quality Aligned with Green Building Standards in Enhancing Students' Well-Being in Higher Educational Institutions

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Abstract

Indoor Environmental Quality (IEQ) in higher educational institutions (HEIs) has attracted the attention of various groups. But, studies were found to be fragmented, focusing on a single IEQ parameter only. Therefore, a more in-depth investigation to comprehend the relationship between IEQ, students' well-being, and quality of life (QoL) is still required. In this study, a qualitative approach was employed for data collection and analysis to obtain a broad understanding of the effects of sustainable IEQ on students' well-being, and retrofitting strategies using green building certification from two Malaysian private universities. The findings revealed that IEQ affects students' well-being, academic performance, and the general experience within HEIs. The efforts to promote IEQ by focusing on such parameters as ambient conditions, designed and behavioral environment, can help HEIs to design the spaces that are not only sustainable in their environmental impact, but also promote academic excellence and overall well-being. This study supports the policy-makers in HEIs to redefine the conventional IEQ characteristics into positive students' well-being and QoL. By understanding the green nudges framework, policy-makers can adapt specific micro-interventions into all levels of planning of a campus, thereby aligning with green building practices.

Keywords: *Indoor Environment Quality, Student Well-being, Education Quality, Green Nudges, Retrofitting.*

Introduction

Higher Education Institutions (HEIs) are increasingly recognized as strategic hubs where significant emphasis is placed on enhancing Indoor Environmental Quality (IEQ) to create healthier, more sustainable, and conducive learning environments (Sirror et al., 2024). This conforms with the emerging demand for green building solutions that balance environmental needs and foster a conducive and healthy environment for students. A green campus, when narrowed down to IEQ, emphasizes creating a healthy, conducive, and sustainable indoor environment by refining its built environment. This approach is incorporated into campus policies, building designs, and daily operations to foster occupant well-being and productivity, thereby becoming an important part of the general campus sustainability initiatives (Fachrudin & Fachrudin, 2021).

IEQ is a major factor influencing students' daily lives, physical and mental well-being, academic performance, and overall Quality of Life (QoL) (Kapoor et al., 2021). Since students spend most of their time indoors, IEQ plays a vital role in supporting their well-being (Esfandiari et al., 2021). In educational settings, factors such as ambient conditions, the designed environment, and the behavioural environment strongly affect cognitive function, productivity, and satisfaction. However, research on this topic is still limited (Laiche et al., 2023).

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Most past studies examined IEQ in isolation, focusing mainly on ambient conditions (Diaz et al., 2021). Despite this, they consistently highlighted the importance of a conducive learning environment for student well-being and performance. For instance, Sirror et al. (2024) studied how occupants' satisfaction with IEQ factors (thermal, lighting, air quality, and acoustics) in a green university related to their overall experience. Similarly, Brink et al. (2023) explored the connection between IEQ and both students' and lecturers' perceived responses and performance. In Malaysian HEIs, Ismail et al. (2019) found that improvements in air quality, natural lighting, and temperature control positively affected students' cognitive performance. Other studies done on a single IEQ parameter: Vella-Brodrick and Gilowska (2022) analyzed the effects of nature intervention on cognitive functioning using a PRISMA-guided systematic review of literature. Papaioannou et al. (2023) assessed the influence of physical learning spaces, varying space and seating, and also classroom designs on teaching and learning outcomes. Gulwadi et al. (2019) conducted a correlation study between campus green spaces and QoL of students in Turkey and the United States, and found that there is a positive correlation between the two factors. Boyd (2022) conducted a mixed-method approach in examining the role of nature and its effects on students' health and well-being. Zhang et al. (2023) also conducted an empirical study on the relationship between students' well-being and green spaces in campuses. Therefore, this research attempts to investigate the contribution to enhancing educational environments through the retrofitting strategies. Specifically, the study will address the following research objectives:

1. To integrate the impact of IEQ parameters on students' well-being, QoL, and learning experience in educational environments.
2. To examine the relationship between IEQ parameters and students' well-being in HEIs.
3. To explore the most appropriate retrofitting strategies to enhance IEQ in HEIs.

Literature Review

Indoor Environmental Quality (IEQ)

IEQ is, in fact, a broad concept; this concept defines a built space as an environment in which the welfare of its occupants is ensured by the environmental quality of that space. It is defined in general as the condition of air quality, thermal, visual, acoustic comfort and some other related factors (Diaz eta al., 2021; Bortolini & Forcada, 2021). Demonstrating the direct relationship between the IEQ parameters and occupants' well-being has been the goal of many studies (Berquist et al., 2019; Elnaklah et al., 2020; Zhang et al., 2022). IEQ is the overall conditions within a building that affect occupant health, comfort and productivity. It is pivotal for sustainable building practices, and forms the core for green certifications such as GBI (Al-Jokhadar et al., 2023). Broader IEQ encompasses both the overall ambient conditions and spatial design of a building.

The IEQ relevance in the case of educational buildings is due to the effects it has on students' academic performance and well-being. Numerous studies find that IEQ affects students' well-being, academic performance, and the general experience within HEIs (Yewande Bakare & Alibaba, 2020). Therefore, the three key IEQ dimensions of this study are modified as - the ambient conditions, designed environment and behavioral environment which warrant the qualities as well as the functionality of campus spaces, as shown in Figure 1. The parameters of these are critical to ensuring a safe, functional, comfortable indoor environment (Zhang et al., 2022).

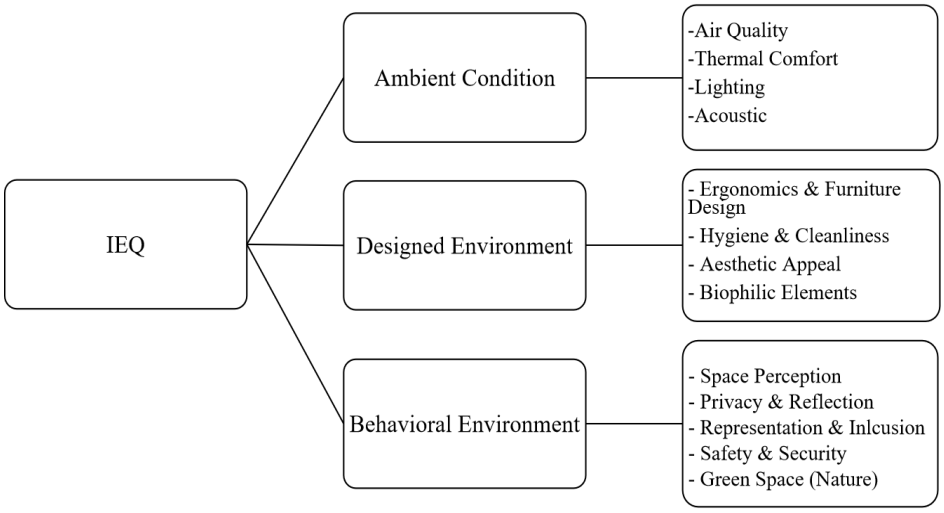

Figure 1: IEQ and its Parameters

Source: Laichee et al. (2023)

2.2 The Relationship between IEQ and Student Well-Being

In the context of HEIs, IEQ is closely related to QoL because individually and collectively, students' well-being, comfort and academic performance are dependent on the psychological and physical IEQ conditions, as indicated by Okanya et al. (2021). This relationship is shown in Figure 2 below:

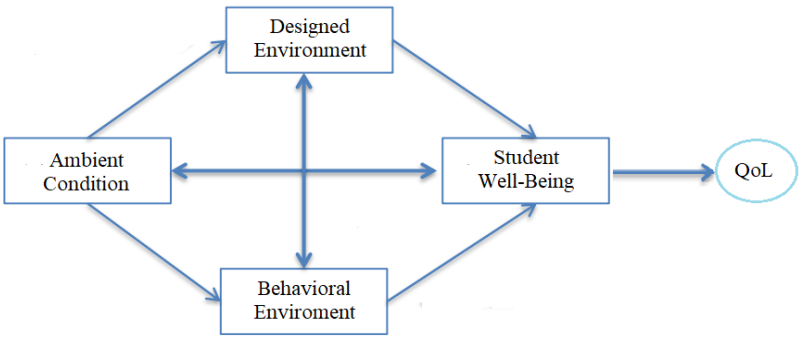

Figure 2. The Relationship between IEQ Parameters, Students' Well-Being and QoL

Source: Mari et al. (2022)

The Relationship between Ambient Conditions and Student Well-Being

Indoor ambient conditions (IAQ, Lighting, Thermal Comfort and Acoustic) are important issues to both the physical health and the psychological well-being of students in HEIs. Indoor air quality affects cognitive function and respiratory health significantly (Tran et al., 2020). A good IAQ reduces the risk of respiratory problems, improves well-being and overall physical and psychological aspects of QoL (Muhammad Nazman et al., 2024). Lighting enhances learning and mood efficiency (Golmohammadi et al., 2021). Daylight exposure in boosting reading and understanding capability has been proven by research, while bad lighting causes fatigue and lowers academic performance significantly (Alvarez, 2020). Good thermal comfort directly alleviates stress and supports physical comfort, and helps with cognitive performance, thereby improving QoL (Bueno et al., 2021). It is well-established that indoor thermal quality in these rooms are key in deciding student's well-being and performance (Bejan et al., 2023). Effective sound control and reduced noise levels, induces concentration, and improves both academic outcome and satisfaction as part of the broader QoL experience (Chan et al., 2021). Studies have found that if the acoustics of the classroom is good, then there would be effective learning (A'Yun et al. (2022).

The Relationship between Designed Environment and Student Well-Being

The designed environment consists of architectural and functional elements (Ergonomic/Furniture Design, Hygiene/Cleanliness, Aesthetic Appeal and Biophilic Elements) which provides the utilization and perception of indoor spaces (Papaioannou et al., 2023). These factors have a substantial influence on student's emotional satisfaction, physical comfort, social interactions (Lopez Chao et al., 2019). Ergonomic support and furniture design plays an important part to maintain physical well-being of students (Mokarami et al., 2022). Furniture which are ergonomically designed enhances good posture and helps for long hours of study. Good physical facilities in classrooms provide productive and successful teaching and learning process (Mustapha et al., 2019). Hygiene and a clean environment in the designed environment cannot be neglected. Good sanitation and hygienic environment foster peace of mind, which is very important to enhance both emotional and physical well-being, leading to a enhanced Quality of Life (QoL) (Moelyaningrum et al., 2023). Spaces that provide a positive, conducive environment for learning and social interaction must be created. When the environment is well-designed and aesthetically pleasing, it not only promotes a better overall mood, but also increases inducement, involvement and sense of pride with the HEIs (He et al., 2024).

The Relationship between Behavioral Environment and Well-Being

The behavioral environment (Space Perception, Privacy, Inclusivity, Safety and Green Spaces) relates to the way students interact with and experience the surroundings and their peers within it. This element of the environment contributes very much to the social engagement, psychological health, and in general sense of well-being that would consequently enhance QoL (Asim et al., 2023). Besides IEQ, the spatial layout and functionality (how classrooms' spatial space and equipment support meet students' needs) can affect students' cognitive (evaluation of the course) and affective/emotional (degree of satisfaction) evaluations of the satisfaction of the course (Makaremi et al., 2024). In the case of academic setting where interaction and focus are keys, the size of the learning spaces contributes to the sense of well-being (Gad et al., 2022). The presence of quiet private spaces that permit retreat, relaxation, opportunities for reflection, are essential to lowering stress and helping students manage emotional well-being, and to feel a sense of self-control (Thelin, 2020). The inclusive and representation of varying cultural diversity in HEIs are important in supporting a harmonious social atmosphere. This produces an inclusive climate, which promotes lively social interactions, and it encourages emotional satisfaction and a community where all students feel valued (Filippou et al., 2025). Emotional well-being and psychological health cannot be promoted without having access to green spaces and contact with nature. Boyd (2022), stated in his study that being near to green spaces and nature has a revitalizing effect on humans. These spaces are great means of escapism, serving as a much needed break from the tensions of academic demands.

Retrofitting with Green Building Index (GBI)

Malaysia's national rating tool for green buildings, the Green Building Index (GBI), was created to encourage the practice of sustainable building in the country (Abd. Hadi et al., 2024). GBI rating tool proposes the enhancement of general design of buildings, reward innovations in environment protection, contributes to the diminution of adverse effects on the nature, and ensures both the new and old buildings are functional and environment-friendly (Lim & Lee, 2024). Figure 3 illustrates the GBI certification which uses six criteria to evaluate buildings to assess their sustainability performance within several categories (Abdulaali et al., 2020; Ha et al., 2023).

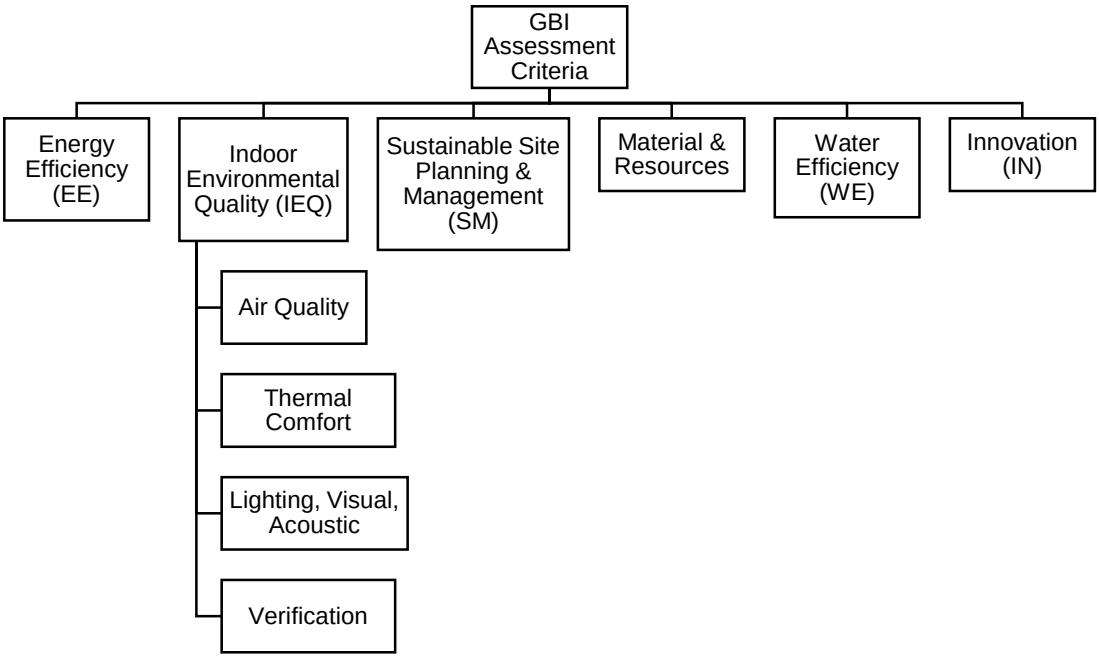

Figure 3. Green Building Assessment

Source: Ha et al. (2023)

Although the GBI certification framework comprises six key criteria, this paper focuses exclusively on Indoor Environmental Quality and Innovation, as they are most relevant to the study's objectives. HEIs may evaluate and enhance the indoor environment by utilizing the Non-Residential Existing Building (NREB) tool to enhance students' well-being. Even though, several universities, schools, and other educational institutions have adopted green building practices, others are struggling to meet the requisite criteria (Barnett-Itzhaki et al., 2025).

Retrofitting with the GBI standards is the process of enhancing the existing buildings, systems or structures to meet their performance, functional or sustainability needs (Sharma et al., 2022). It can be very beneficial in the context of educational buildings, especially in improving aged facilities with an improved learning environment and a conducive environment for student well-being and learning environment (Iwuanyanwu et al. 2024; Ejidike et al., 2025).

Table 1 to Table 3 demonstrates the proposed retrofitting measures aimed at fostering IEQ in HEIs. The proposed strategies are based on best practices to enhance IEQ in the educational environment.

Table 1: Proposed IEQ Retrofitting for Ambient Conditions

IEQ Component	Key Factors	GBI-Based Retrofitting Strategies
Ambient Condition	Air Quality	Install HEPA filters, increase natural ventilation, install materials with few VOCs, add biophilic design (green walls, plants).
	Thermal Comfort	Upgrade to automated heating, ventilation, and air-conditioning (VRF systems), apply phase change material (PCM), introduce high performance glazing, sun shading.
	Lighting	Use induced LED light with sensors, up the daylighting (light shelves, skylights)- and change color temperature to benefit well-being.
	Acoustic	Place noise-absorption panels, install windows with the double glazing, apply acoustic zoning to design layout.

Source: Krietemeyer (2024); Sun et al., (2025); Tsirigoti et al. (2020).

Table 2: Proposed IEQ Retrofitting for Designed Environment

IEQ Component	Key Factors	GBI-Based Retrofitting Strategies
Designed Environment	Ergonomics & Furniture Design	Opt for sit-stand desks, adaptable/adjustable and ergonomically-designed furniture and ample learning environment spaces.
	Hygiene & Cleanliness	Use antimicrobial paints, enhance solid waste handling, and institute frequent cleaning procedures.
	Aesthetic Appeal	Employ color psychology, natural textures, and environmental-friendly materials.
	Biophilic Elements	Incorporate the use of green roofs, indoor plants, courtyard gardens and natural ventilation techniques.

Source: Bai et al., (2021), Yong & Calautit (2023), McGee & Park (2022), Asojo & Hazazi (2025)

Table 3: Proposed IEQ Retrofitting for Behavioral Environment

IEQ Component	Key Factors	GBI-Based Retrofitting Strategies
Behavioral Environment	Space Perception	Design space freely and flexibly as a way to enhance individualized and collaborative learning environments.
	Privacy & Reflection	Provide quiet study areas, soundproof rooms, and relaxation areas.
	Representation & Inclusion	Ensure open access, cross-cultural designs, and gender inclusive facilities
	Safety & Security	Install intelligent security, improve contingency exits/lighting and secure access entry controls.
	Green Space (Nature)	Devise outdoor study zones, covered pathways, rooftop gardens and eco-corridors.

Source: Fuchs et al., (2024), Mondaini & Duranti (2024), Asojo & Hazazi (2025)

Theoretical Framework for Incorporating Green Nudges

Green nudges are specific tools used within behavioral economics to influence decisions. It is designed to promote environmentally friendly actions by subtly altering the decision-making environment without restricting options or significantly changing economic incentives (Wee et al., 2021). These interventions leverage insights from behavioral economics to encourage sustainable behaviors, such as reducing energy consumption, minimizing waste, or choosing eco-friendly products (Enste & Potthoff, 2021). These nudges have gained prominence as a tool for bridging the intention-action gap, where individuals express a desire to engage in sustainable behaviors but struggle to follow through. Figure 4 illustrates how a theoretical framework can be converted into a operational framework. The framework is initiated through green nudges, which can create awareness among educational policy makers and consequently induce pro-environment behaviors. This awareness and altered behaviors result in the adoption of retrofitting initiatives focusing on improving the built environment within HEIs.

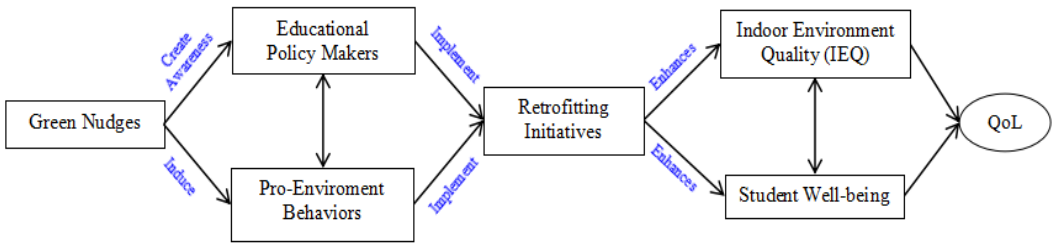

Figure 4: Theoretical Framework

Adapted from: Patil et al. (2024)

Integrated Strategies for the Application of Green Nudges in Enhancing IEQ in Educational Buildings

Behavioral economics offers valuable insights for decision-makers seeking to enhance IEQ in educational buildings. Green nudges can help decision-makers better evaluate costs and benefits and decide on their priorities, thus improving the final end result. By understanding how environmental conditions, building design, and human behavior influence comfort, productivity, and sustainability, decision-makers can adopt strategies that promote better outcomes for occupants. Table 4 outlines some strategic approaches in integrating green nudges intended at assisting educational policy-makers in implementing IEQ retrofitting initiatives.

Table 4: Integrated Strategies Using Green Nudges

Category	Green Nudges	Strategies	Example Applications for Universities
Ambient Conditions	**Default Choice**	Ensure that energy-efficient restoration is the norm of the renovation plans	Set LED lighting and motion-sensor controls as the default choice in every upgrade package.
	Framing	Emphasize retrofits as crucial to the well-being of students.	Highlight past studies to demonstrate that a higher IEQ promotes mental performance and reduces stress.
	Social Influence	Showcase examples of how other universities implement retrofitting and green campus programs.	Present evidence of the progress of performance metrics and the favorable campus environment of peer universities after retrofits.
Designed Environments	**Loss Aversion**	Highlight the financial and reputation risks of ignoring retrofitting measures.	Emphasize the disadvantages in failure to retrofit - increased operational costs and losing out in building the university's reputation for green campus.
	Nudging	Advertise retrofits by stressing the long-term benefits for campus resilience and the broader community welfare.	Showcase evidence - prototypes and visual on lower energy costs and fostering green campus appeal through retrofitting.
Behavioral Environment	**Incentives**	Acknowledge and reward recognition for departments/faculties championing green campus initiatives	Offer sustainability awards for departments/ faculties implementing green campus projects.
	Framing	Highlight the long-term environmental effect of green campus and cost savings for the university.	Display data on retrofitted reduction in operational and utility costs.

Adapted from: OECD (2017)

Studies revealed the potential impact of "green nudging" as a powerful tool in influencing decision-makers to adopt sustainable practices and enhance indoor environmental quality in educational institutions (Santos Silva, 2022). Green nudges are subtle interventions that encourage environmentally responsible choices while preserving autonomy in decision-making. Policymakers and university

administrators can leverage these behavioral insights to drive large-scale implementation of GBI-certified retrofits. By framing sustainability as a long-term investment, embedding green defaults in procurement decisions, and aligning incentives with institutional goals, decision-makers can foster healthier and more sustainable learning environments while ensuring regulatory compliance and operational efficiency (Bar et al., 2022).

Methodology

A qualitative approach was employed for data collection and analysis to obtain a broad understanding of the effects of sustainable IEQ on students' well-being, and retrofitting strategies using green building certification. Figure 5 illustrates the general research design used in this research. Every stage shows how the methodological steps may be connected to present validity, reliability, and consistency with the research questions.

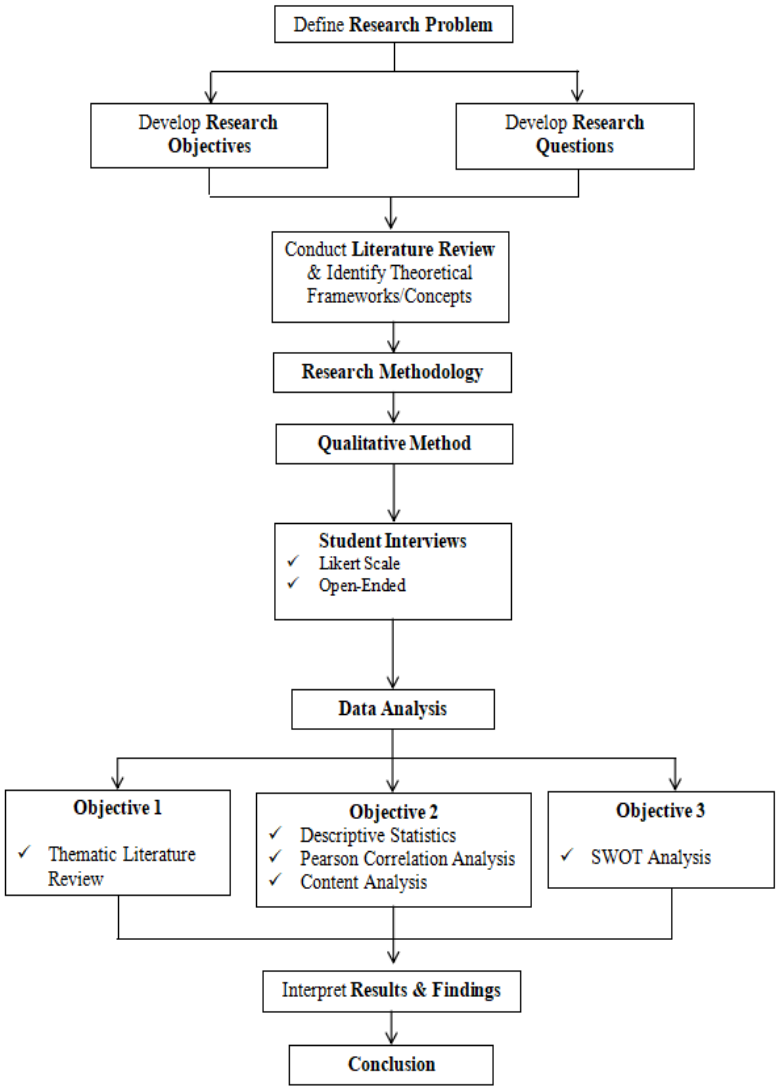

Figure 5: Research Design

Data Collection Methods

Data was collected using interviews and open-ended questions from two selected private universities. A total of 30 students were interviewed from these private HEIs, comprising 5 point Likert scale and open-ended questions. Such a sample size was chosen for the sake of representativeness and feasibility of the study within the study time-frame.

Secondary data collection was done using documented sources and existing data that are pertinent to the research objectives. A thematic literature review was conducted in an attempt to explore

and summarize what was already known about the topic. Thematic reviews facilitate the integration of literature from various disciplines, offering a holistic view of the topic.

Data Analysis

Response Rate and Timeline

35 individuals were invited to participate in the qualitative interview, 30 agreed to participate and underwent the interviews, registering a 86% of positive response rate. This fairly large participation rate indicates a high level of involvement and interest in the respondents, which reinforces the validity and credibility of the qualitative information collected.

Reliability Test

Table 5 present the results of the reliability test done on the interview questions to determine the internal consistency of the items grouped under different dimensions. Cronbach's Alpha is used to calculate the composite reliability, which measures how the items in each dimension correlate and reliably measure the underlying construct.

Table 5: Reliability Test for Interview Questions

Dimension/Items	Number of Items	Reliability (Cronbach's Alpha)
Ambient Conditions	13	0.823
Designed Environment	7	0.832
Behavioral Environment	8	0.864
Overall Quality of Life e	6	0.950

Interpretation of Cronbach's Alpha Values (Setyaedhi, 2024)

- 0.70–0.79: Acceptable reliability
- 0.80–0.89: Good to excellent reliability
- 0.90 and above: Exceptional reliability

The Cronbach's Alpha values for each construct are between 0.823 and 0.950 for all dimensions, therefore, it indicates high internal consistency of the interview questions, and shows that it is a reliable tool for measuring the intended construct. Thus, the results present a degree of confidence that the data collected can be used for robust analysis and that the items within each dimension consistently reflect their constructs.

Thematic Literature Review

Numerous studies find that IEQ affects students' well-being, academic performance, and the general experience within HEIs (Yewande Bakare & Alibaba, 2020). The commonality in the literature is the awareness of the importance of using a multi-dimensional approach to IEQ by considering physical conditions, design characteristics as well as behaviour in the ongoing pursuit of a healthier, nurturing and productive learning environment (Hashemi & Dungrani, 2025).

Demographic

Tables 6 and 7 describes the demographic profile of 30 respondents from private universities. Most of the respondents are from different academic programs, with Engineering being the most common field of participants, followed by Business, Others, and Architecture. In addition, the respondents mainly comprise of second year students (50%), followed by third year (23.33%), fourth year (16.67%), and first year (10%), which represents a wide spread in all the years of study. This robust demographic composition clearly lays a good foundation to discuss the Likert scale responses in this study.

Table 6: Program of Study

Category	No. of Respondents	Percentage %
Engineering	10	33.33
Architecture	4	13.33
Business	9	30
Others	7	23.34

Total	**30**	**100**

Table 7: Year of Study

Category	**No. of Respondents**	**Percentage %**
Year 1	15	10
Year 2	3	50
Year 3	7	23.33
Year 4	5	16.67
Total	**30**	**100**

IEQ Parameters and Their Impact on Students' Well-being

The second research objective of this study is to examine the impact of IEQ on students' well-being. Three systematic phases are aimed at the calibration of this objective, namely descriptive statistics, Pearson correlation and content analysis.

Descriptive Statistics Summary for IEQ Parameters

The descriptive statistics shows the pattern of the general trend of the data and how the data is distributed among the IEQ variables in the contexts of its relationship with student well-being. Table 8 presents the ranking of the IEQ variables based on the descriptive statistics outcomes.

Table 8: Ranking of IEQ Variables based on Mean Scores

Variables	**Mean**	**SD**	**Rank**
Green Spaces	4.10	0.803	1
Indoor Air Quality	3.76	0.756	2
Acoustic Quality	3.73	0.528	3
Inclusivity/Cultural Identity	3.66	0.844	4
Hygiene/Cleanliness	3.60	0.865	5
Safety/Security	3.60	0.674	5
Perception of Space	3.58	0.891	6
Furniture/Ergonomics	3.50	0.579	7
Personal Spaces	3.50	0.900	7
Thermal Comfort	3.46	0.756	10
Lighting	3.44	0.678	11
Aesthetic Appeal	3.43	0.897	12
Opportunity for Privacy	3.41	0.881	13

It can be concluded that students emphasize to a large degree the factors that add resolute value to the general environmental quality and user experience of their campus, or in other words, their perceived importance. The existence of nature and greenery (M=4.10) is considered highly perceived as students appreciate the environment that fosters well-being and feel connected with nature. Air quality (M=3.76), acoustics (M=3.73), and cultural inclusivity (M=3.66) also appeared as important to students, which suggests that physical comfort and social interactions of campus spaces are acknowledged. Practical concerns such as hygiene/cleanliness (M=3.60), safety/security (M=3.60) and furniture/ergonomics (M=3.50) show that students are sensitive to factors that influence their day to day usability and comfort. In contrary, the attributes that concern the existence of more specific thermal conditions (M=3.46), lighting (M=3.44), aesthetics (M=3.43), or opportunities for privacy (M=3.41), although important, are trivial compared to other environmental attributes. But it is also worth mentioning that this does not imply that these attributes are unimportant. Instead, it indicates that in the given group and within specified context settings, students are more inclined to pay attention to other variables of the environment and social background in terms of their general comfort and satisfaction with the campus environment. These parameters are critical to ensuring a safe, functional, comfortable indoor environment (Zhang et al., 2022).

Pearson Correlation Summary for IEQ and Student Well-being

The purpose of this analysis is to examine the relationships between IEQ parameters (ambient conditions, designed environment and behavioral environment) and indicators of student well-being (such as concentration, stress levels and productivity). The strength of the Pearson correlation is depicted in Table 9.

Table 9: Strength of Pearson Correlation

Correlation Coefficient (r)	Strength of Correlation
0.00 to ±0.19	Very Weak (or None)
±0.20 to ±0.39	Weak
±0.40 to ±0.59	Moderate
±0.60 to ±0.79	Strong
±0.80 to ±1.00	Very Strong

Source: Papageorgiou (2022)

Table 10 presents the ranking of the IEQ variables based on the Pearson correlation outcomes.

Table 10: Ranking of IEQ Variables based on Pearson Correlation

Variables	**Pearson - r**	**Ranking**
Thermal Comfort	0.746**	1
Lighting	0.732**	2
Personal Spaces	0.698**	3
Indoor Air Quality	0.675**	4
Acoustics	0.613**	5
Perception of Space	0.595**	6
Opportunities for Privacy	0.579**	7
Aesthetic Appeal	0.449*	8
Inclusivity/Cultural Identity	0.342	9
Safety/Security	0.287	10
Hygiene/Cleanliness	0.253	11
Green Spaces	0.214	12
Furniture/Ergonomics	0.133	13

**Correlation is significant at 0.01 level (2-tailed) N=30

It how the aspects of thermal conditions (0.746) and lighting (0.732) appear to have a stronger correlation to the overall relationship with students' well-being. Significant correlations are also shown by personal spaces (0.698) and air quality (0.675), concluding that the physical comfort and the quality of the environment determinants are important to students' well-being. Acoustic quality (0.613), space perceptions (0.595), and opportunities for privacy (0.579) are other aspects that underline the significance of visual and psychological aspects in fostering students' campus experience. Although aspects such as aesthetics (0.449), cultural identity (0.342), safety (0.287) and hygiene/cleanliness (0.253) are also pertinent, they seem to show a rather minor influence in this particular context. Equally, elements such as green areas (0.214) and furniture/ergonomics (0.133) appear to serve a more supportive purpose, meaning that students might be more inclined to focus on the functional comfort and on the environment attributes in general, than on the these aspects when it comes to the overall relationship with their well-being. To summarize, these difference in perception reveal that not all aspects of the environment are perceived by students as equally influential to them; some circumstances (such as comfort and lighting) obviously have a greater impact when it comes to shaping their experiences or perceptions and others are viewed as supportive attributes. Demonstrating the direct relationship between the IEQ parameters and occupants' well-being has been the goal of many studies (Berquist et al., 2019; Elnaklah et al., 2020; Zhang et al., 2022).

Content Analysis on IEQ and Student Well-being

The study employed manual qualitative content analysis, where the open-ended responses and experience-related feedback were manually interpreted on how the quality of IEQ influenced the perception of well-being and QoL of students. Table 11 provides qualitative insight into the themes, frequency, and percentages of occurrence for the various aspects of the IEQ parameters.

Table 11: Themes/Codes, Frequencies, Percentage

Variables	Themes	Frequencies	Percentage (%)
Air Quality	Fresh	21	70.0
	Stagnant	9	30.0
	Odours	8	26.7
	Ventilation	16	53.3
Lighting	Bright	22	73.3
	Glare	11	36.7
	Dim	8	26.7
Thermal Comfort	Comfortable	26	86.7
	Warm	10	33.3
	Air Conditioning	22	73.3
Acoustic Quality	Quiet	18	60.0
	Noise	16	53.3
	Distraction	9	30.0
Furniture/ Ergonomics	Adjustable	8	26.7
	Comfortable	21	70.0
	Old	6	20.0
Hygiene/ Cleanliness	Clean	24	80.0
	Hygiene	19	63.3
	Regular Cleaning	11	36.7
Aesthetic Appeal	Decorated	16	53.3
	Welcoming	12	40.0
	Plants	10	33.3
Perception of Space	Ample space	18	60.0
	Congested	7	23.3
Opportunities for Privacy	Privacy	15	50.0
	Personal Space Sitting Arrangement	11 8	36.7 26.7
Inclusivity/ Cultural Identity	Posters Representation	9	30.0
	Diversity	8	26.7
	Belonging	11	36.7
		7	23.3
Safety/Security	Safe	27	90.0
	Emergency exits	10	33.3
Green Spaces	Greenery	17	56.7
	Relax	15	50.0
	Nature	11	36.7
Personal Space	Outdoor	16	53.3
	Break	14	46.7

The perceptions of the students concerning the IEQ such as thermal comfort (86.7% felt comfortable), safety (90% felt safe), cleanliness (80% is clean), and bright lights (73.3%), are quite highly satisfied, similarly fresh air quality (70%) and greenery (56.7%) are also satisfying. Nevertheless, the some issues can be found in several areas which include inconvenience in noise and distractions (53.3% and 30%), glare and poor lighting (36.7%), stagnant air (30%), aged furniture (20%), lack of personal space (36.7%), and varied views on cultural representation (26.7%). On the whole, the results points to the strengths in terms of comfort, safety, and hygiene but indicate the need to improve the aspects of the acoustic environment, ergonomic furniture, privacy, and more inclusive and aesthetically appealing environment. These insights underscore the importance of optimizing IEQ, particularly in educational settings, where students' well-being and cognitive performance are directly impacted (Amoatey et al., 2024). Table 12 provides qualitative insight into how students view various aspects of their well-being and QoL.

Table 12: Well-being and QoL

Variables	Codes/themes	Frequencies	Percentage (%)
Physical Well-Being	Healthy	11	36.7
	Comfort	24	80.0
	Safety	16	53.3

Mental Well-Being	Mood Focus Stress	24 13 11	80.0 43.3 36.7
Academic Performance	Concentration Good results	26 25	86.7 83.3

The table indicates that for Physical Well-Being, the majority of students feel comfortable (80%), safe (53.3%), and healthy (36.7%). Mental Well-Being shows that the positive mood is high (80%), whereas focus (43.3%), and stress (36.7%) show mixed experiences. In the case of Academic Performance, concentration (86.7%) and good results (83.3) are widely encountered, indicating that the overall academic performance is good. In the context of HEIs, IEQ is closely related to QoL because individually and collectively, students' well-being, comfort and academic performance are dependent on the psychological and physical IEQ conditions, as indicated by Okanya et al. (2021).

SWOT Analysis: Integrating Descriptive, Pearson, and Content Analysis

The third objective of this research is to explore the most appropriate retrofitting strategies to enhance IEQ in HEIs. It is completed by developing a critical analysis of the strengths, weaknesses, opportunities and threats (SWOT) based on the results of the descriptive statistics, Pearson correlation and qualitative content analysis. Combining the results of the three analysis, the SWOT analysis intends to present a holistic comprehension of what contributes to or suppresses effective implementation of retrofitting strategies to enhance IEQ and student's well-being. The green nudges framework that was developed to address the study is also advocated for it application, making sure that the findings are interpreted in a critical way to offer useful insights to facilitate retrofitting initiatives in the future would be more student-focused and geared toward the improvement of well-being and academic achievement. Table 13 presents the SWOT analysis based on the students' responses, highlighting key environmental strengths, persistent challenges, actionable opportunities, and ongoing threats within the educational setting.

Table 13: SWOT Analysis

Strengths	**Weaknesses**
• Lecture rooms are usually comfortable in terms of temperature and the majority of the students gave high rating for this. • Lighting fosters positive mood and productivity. • Students note that they are mentally relaxed and feel safe within the campus. • The environment is subjectively viewed as inclusive and culturally considerate, with high ratings for these dimensions.	• Noise control is lacking in some of these areas and the number of students who gave acoustic comfort a low rate was high. • Certain furniture in the lecture room causes discomfort or physical strain. • There is lack of privacy in study areas as it is rated either as mixed or low. • Washroom hygiene and maintenance are irregular, with some students discontent.
Opportunities	**Threats**
• Replenishment of green zones and outdoor studying spaces is highlighted by students. • One potential solutions is to make improvements to the ergonomics/furniture to offer more comfortable seating arrangements. • More quiet zones and privacy pods will need to be added in order to facilitate focused learning.	• Poor maintenance can diminish students' impression of their campus. • Constant noise interruptions have adverse concentration and learning outcomes. • Poor IEQ has been associated with mental strain and impacts well-being.

In summary, it is noted that students value comfortable temperatures, proper lighting that fosters good mood, productivity, conducive and safe environment, and an atmosphere that makes them feel welcome on campus. There are however, drawbacks such as lack of noise control, uneasy furniture, inadequate privacy in study places as well as inconsistent washrooms sanitation. There are also opportunities to make green spaces, enhance furniture/ergonomics and provide more quiet zones and privacy pods to ensure concentrated learning. The threats relate to the possibility that substandard maintenance, excessive noise, and the general low-level IEQ will have an adverse impact on the concentrations of students, their learning performance and their overall well-being

Theoretically, this paper developed the green nudges framework by demonstrating how students' well-being and QoL can be influenced by the strategically applied micro-based interventions implemented in campus retrofits based on the findings of the SWOT analysis. To the educational policy makers, this framework serves not as a theory, but a well-evidenced tool in the process of establishing design standards, retrofitting requirements, and operating policies at campuses.

Discussion

Key Findings for Objective 1: To integrate the impact of IEQ parameters on students' well-being, QoL and learning experience in educational environments.

A thematic literature review was conducted in an attempt to explore and summarize what was already known about the topic. Numerous studies find that IEQ affects students' well-being, academic performance, and the general experience within HEIs (Yewande Bakare & Alibaba, 2020). IEQ is the overall conditions (ambient conditions and spatial design) within a building that affect occupant health, comfort and productivity (Al-Jokhadar et al., 2023). Furthermore, IEQ practices focused on sustainability are seen as consistent with global goals for environmental responsibility and sustainable development (Abdelmajeed et al., 2023). Therefore, improving IEQ through good design plus contextually specific technologies and policy supports has many advantages.

Key Findings for Objective 2: To examine the relationship between IEQ parameters and student's well-being in HEIs.

The descriptive statistics indicated that the students perceived the ambient conditions, designed environment and behavioral environment in their institution of higher learning as moderate to fairly good. Inferences by the Pearson correlation analysis indicated that IEQ variables, especially ambient conditions, were associated positively and highly with student well-being and satisfaction. In comparison, others variables of the designed and behavioral environment related less strongly or not significantly, indicating their effect to be more subtle or context specific. The apparent student responses provided in the content analysis demonstrated how students perceive their lives on a day-to-day basis, highlighting the underlining codes/themes such as freshness, bright, comfortable, noise, hygiene and the likes.

Key Findings for Objective 3: To explore the most appropriate retrofitting strategies to enhance IEQ in HEIs.

Lastly, these findings were summarized in the SWOT analysis that revealed the strengths, weakness, opportunities and threats, obtained from the responses. The green nudges framework proposed can provide an innovative, student-focused approach to educational policy-makers who aspire to develop an educational environment that is restorative, inclusive and supportive of student success in HEIs.

Conclusion

It revealed that IEQ affects students' well-being, academic performance, and the general experience within HEIs. In other words, IEQ is the overall conditions (ambient conditions and spatial design) within a building that affect occupant health, comfort and productivity. This study presents a holistic structure of explaining how the IEQ factors play a significant role in retrofitting the educational infrastructure. The efforts to promote IEQ by focusing on such parameters as ambient conditions, designed and behavioral environment, can help HEIs to design the spaces that are not only sustainable in their environmental impact, but also promote academic excellence and overall well-being. These results offer a guide for future retrofitting plans, integrating pragmatic recommendations and visionary insights in creating resilient and student-focused learning environment.

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