# Evaluation of Indoor Environmental Quality of Hostel Rooms and its Effects on Students' Wellbeing in Selected Universities in Oyo State, Nigeria

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**Being a PhD Thesis Submitted to the Department of Architecture, Faculty of Environmental Design & Management, Lead City University, Ibadan, Oyo State, Nigeria**

**In Partial Fulfilment of the Requirements for the Award of Doctor of Philosophy Degree (PhD) in Architecture**

**2025**

## Certification

This is to certify that David Olaolu OGUNTUNDE with matriculation number LCU/PG/002813 carried out this research work titled "Evaluation of Indoor Environmental Quality of Hostel Rooms and its effect on Students' Wellbeing in Selected Universities of Oyo State, Nigeria" in the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo state, for the award of Doctor of Philosophy Degree (PhD) in Architecture and that this work has not been previously submitted.

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Prof. Oluwole Alagbe Date

Supervisor

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Head of Department

**Dedication**

This research work is dedicated to my late mother, Deaconess Alice Jayeade Oguntunde.

## Acknowledgement

I appreciate Lead City University, Ibadan, for providing a platform for this work to be done. I also acknowledge the support and contribution of both the institutions and student hostels' managements of Lead City University, Ibadan; University of Ibadan; Abiola Ajimobi Technical University, Ibadan (formerly, First Technical University) and Ajayi Crowther University, Oyo, for the permission granted to collect data and relevant information necessary for the successful completion of this thesis. I would like to express my appreciation to both academic and administrative staff of the Postgraduate College, Lead City University, Ibadan.

I gratefully acknowledge the invaluable assistance, contributions, constructive critisism and effort of my supervisor, Professor Oluwole Alagbe, towards the accomplishment of this thesis. Thank you so much sir, your efforts cannot be emphasized. I also appreciate the dedication of the Head of Department, Dr Dare Obaleye, Postgraduate Coordinator, Dr. Oluwatosin Ayanleke, and other staff, who in one way or the other made this programme a huge success.

I am greatly indebted to my only intimate friend, partner and honey, Deaconess Felicia Olubola Oguntunde, for her moral & spiritual support and encouragement throughout the period of this programme. Also, to my Children, David-Snr Oluwasemiloore Oguntunde and Sharon Olawalarami Oguntunde, for bearing with me throughout the period of this PhD programme.

To all my amazing family, friends and course mates (too numerous to mention by name), who contributed immensely in making this programme a huge success, you are all important and great. A big thank to you all.

Even though, this research wouldn’t have been a success without assistance from the above mentioned, I alone stand liable for all errors, if any, found in this work.

**Abstract**

Acceptable Indoor Environmental Quality (IEQ) is needed for occupants' quality sleep, health, comfort and wellbeing. This study examined hostel rooms' Indoor Environmental Quality and its effects on students' wellbeing in selected universities in Oyo State, Nigeria. It specifically investigated the orientation of the hostel building with physical dimensions of the hostel rooms and examined the adequacies of IEQ components. It further investigated the students' satisfaction with the IEQ conditions and established the impacts of IEQ conditions on students' wellbeing. Data was collected through both primary and secondary sources including physical measurements of hostel rooms' layout and questionnaires. A Two-stage sampling technique was used to select the students as study population. 1410 questionnaires were randomly distributed based on Probability Proportional to Size while 1372 (97.3% of the sample size) questionnaires were retrieved and analyzed. The data obtained from both objective and subjective measurements were quantitatively subjected to descriptive, explorative and inferential statistics in frequencies, percentages and cross-tabulations in tables and regression analysis using Statistical Package for Social Science (SPSS 23.0). It was found that all hostel halls exhibit diverse characteristics such as building orientation, geometry/form; number of floor; number of loading; headroom etc and greatly influenced IEQ conditions in the hostels, thereby, enhancing students' satisfaction and wellbeing. Also, the IEQ components of thermal comfort, IAQ, acoustic and lighting were inadequate, unsatisfactory and uncomfortable in most of the hostel spaces due to inadequate percentages of window/wall and window/floor area ratios, though; indoor ventilation was assessed and found to be adequate in the hostel rooms. The result further revealed unsatisfactory thermal conditions, unhealthy indoor air quality and high level of noise disturbance thus, affecting students' wellbeing, though, artificial lighting was adequate and satisfactory. Findings further revealed that the students' wellbeing is strongly affected by unhealthy IEQ as reflected by the students' sleeping inefficiency, demotivation to wake up early and ill-health status. It was found that, headache, fatigue, cold hands and feet etc are the prevalent health symptoms in the hostel rooms. Therefore, a strong significant relationship ($p<0.05$) exists between students' wellbeing and IEQ component of thermal, IAQ, acoustic and visual comforts in the hostel rooms establishing IAQ as the most ranked IEQ component contributed to students' wellbeing. The study therefore contributed to the sustainable development and healthy indoor ambiences, aligning with the SDGs 3, 4, 7, 9 and 11 thus, enhancing students' wellbeing. The study recommends that adequate attention must be paid to the inclusion and handling of the IEQ components at the hostels design conceptualization and implementation stages to enhance occupants' sleep quality and health to promote students' wellbeing.

**Keywords:** Hostel Rooms, Indoor Environmental Quality (IEQ), Selected Universities, Students' wellbeing.

**Word Count:** 427

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## List of Acronyms

| Abbreviation | Meaning |
|---|---|
| ASHRAE | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| CERAD | The Consortium to Establish a Registry for Alzheimer's Disease |
| HVAC | Heating, Ventilation, and Air-Conditioning |
| ANOVA | Analysis of Variance |
| AC | Air-Conditioning |
| NV | Natural Ventilation |
| IEQ | Indoor Environmental Quality |
| IAQ | Indoor Air Quality |
| PM | Particulate Matters |
| CITO | Centraal Instituute Toets Ontwikkeling |
| CCT | Correlated Colour Temperatures |
| SVT | Sentence Verification Task |
| SDLT | Serial-Digit Learning Test |
| LED | Light-Emitting Diode |
| SVT | Sentence Verification Task |
| RII | Relatively Importance Index |
| AHP | Analytical Hierarchical Process |
| IQ | Intelligence Quality |
| UI | University of Ibadan |
| ACU | Ajayi Crowther University |
| LCU | Lead City University |
| AATech | Abiola Ajimobi Technical University |

# Chapter One

# Introduction

## 1.1 Background to the Study

Indoor Environmental Quality (IEQ) is a quality of a building's ambience in compliance to the occupants' comfort, sleep quality, satisfaction, wellbeing and productivity[1]. It is further defined as an acceptable level of thermal, lighting/visual, acoustic and Indoor Air Quality (IAQ) comfort[2]. These factors greatly influence occupants' satisfaction, wellbeing & productivity, and are expected to be improved when the quality of indoor environment is conducive to the people in any indoor space[3]. Buildings are constructed for people to reside, sleep, work, study, learn and perform different activities and requirements for the occupants' tenancy are needed to be achieved as a pre-condition for their health, performance, productivity and wellbeing[4]. Based on hierarchy of human's needs, shelter is named as the first important aspect under the physiological need of man among other needs[5]. A building/shelter therefore functions as a habitation of quality sleep and security, and needs to be carefully designed for the wellbeing, satisfaction, and productivity of the occupants[6].

In contemporary times, people spend approximately 60%–90% of their day's life period in indoors and are continuously exposed to various indoor environmental quality[7]. Indoor Environmental Quality (IEQ) has a significant impact on health, wellbeing, mood, satisfaction, productivity and finally on quality of occupants' life. It becomes a matter of great concern if the environment causes any detrimental/negative effect on the building occupants' wellbeing, comfort, satisfaction and productivity[8]. Also, work performance and productivity of occupants are poorly affected when the quality of indoor ambience is slightly affected[9]. There is therefore a need to fully investigate the impact of indoor environmental quality (IEQ) on the occupants' quality life, wellbeing, satisfaction and productivity. Studies have shown that the residents' comfort, satisfaction, performance, quality of lives, health, wellbeing and productivity can be strongly affected by indoor environmental conditions[10]. For instance, inadequate supply of fresh air alone in the commercial buildings of United States and United Kingdom had caused a loss of approximately billions of 38 dollars and 15 pounds respectively as a result of reduced users' productivity, performance and illnesses[3]. Therefore, assessing sustainability in building is important, encompassing economic, social and environmental aspects that can create healthier and more sustainable sleeping and learning environments for the enhancement of productivity and wellbeing in the indoors.

A student housing or hostel, is a lodging facility designed and constructed to meet the essential needs of students in a learning environment. It is a shared educational facility that accommodates students for not less than 8 to 12 hours daily after other learning activities[11]. Further studies revealed that an estimated 60-70% of students' daytime are spent within the hostel indoor for mutual reading/studying, engaging in assignments, sleeping and preparing for other day's academic works [12, 7]. It is also revealed that shelter (hostel) and its indoor conditions influence its occupants' wellbeing, comfort, satisfaction, health, and enhances motivation to learning[13]. Therefore, it is imperative to explore the influence of indoor environmental components on residents' comfort and satisfaction to enhance wellbeing and performance in the indoor. Students' hostels are therefore not in exemption of these adverse effects associated with exposures to poor indoor environmental quality, hence, emphasizing the importance of creating acceptable indoor environmental conditions. This is to create comfort, satisfaction and wellbeing for these hostel buildings where students' intellectual capacity and learning performance are enhanced[14].

In current times, studies on indoor environmental quality (IEQ) in students' hostels have gained momentum because IEQ plays an important part in determining the level of students' satisfaction in the dormitories, thus, establishing a strong correlation to students' wellbeing, performance and productivity[1]. Researches revealed that poor IEQ (air quality, lighting, acoustics, and thermal comfort) in hostels may result to discomfort, dissatisfaction and poor wellbeing, as a result of adverse health symptoms[15]. On the converse, quality indoor ambiences have a significant role on occupant wellbeing, health, comfort, satisfaction, performance and productivity[16]. Quality and excellent daytime functioning with sound health, adequate and unobstructed sleep are functions of enhanced satisfaction, wellbeing and performance[17]. Consequently, quality sleep is very vital for human health & wellbeing and a basic human need for productivity, performance and learning motivation[18]. It is therefore necessary to give good consideration in achieving satisfactory indoor environmental quality in students housing to aid their wellbeing and enhanced performance.

## 1.2 Statement of the Problem

Over decades, studies have investigated Indoor Environmental Quality (IEQ) components and their influences on occupants globally. The focus had been on various buildings such as commercial/public buildings, educational buildings, offices and domestic homes, among others[19, 20, 21, 22, 23, 24]. While there are numerous studies on Indoor Environmental Quality (IEQ) and its influences on occupants, there are few studies as it relates to students' hostels when compared to other building types.

In this regard, various researchers have assessed IEQ impacts on occupants in educational edifices like laboratories, staff offices, classrooms etc. For instance, a Malaysian university's three air-conditioned engineering education laboratories were assessed for thermal conditions and health issues associated with building illnesses. Subjective surveys were used in conjunction with objective measurements of mean radiant temperature, relative humidity, and air temperature to compile data on the specific building and users' perceptions[25, 26, 27]. Also, a self-administered questionnaire to capture information among university office staff to examine the association between health symptoms, office characteristics, individual factors, and indoor pollutions in selected universities in Malaysia was performed. A methodology of direct reading instrument was used to measure indoor temperature, relative humidity, carbon monoxide, and carbon dioxide and analysis of chemical toxins from settled dust and mite collected through a vacuum was performed[28, 29, 30, 31, 32].

Furthermore, in the conduct of investigations of IEQ effects on occupants in domestic homes; a study to examine the link between indoor air quality (IAQ) and health problems from sick building syndrome (SBS) in Chinese homes was conducted. The research studied the building characteristics and established a method of measuring the ventilation rate, relative humidity, air temperature, carbon dioxide, particulate matters, volatile organic compounds (VOCs), and ozone with the administration of questionnaires to capture information on residents' perceptions of SBS symptoms and odour[33, 34].

Although, numerous researches have been conducted in diverse dimensions on IEQ components and its various effects on occupants in Africa and globally with focus on domestic homes, offices/commercial, educational buildings and few students' hostels. To the best knowledge and understanding of the author, there exists a paucity of researches on the quality of hostel indoor environment and its influences on the wellbeing of students residing in Nigerian dormitories. This study is therefore aimed at conducting an evaluation of Indoor Environmental Quality (IEQ) components of hostel indoors to determine its influences on students' wellbeing in selected universities, Oyo state, Southwest Nigeria.

## 1.3 Aim and Objectives of the Study

The aim of this study is to evaluate hostel rooms' IEQ components and its effects on students' wellbeing in selected universities, Oyo State, Nigeria.

The objectives were to:

1. determine the compass orientation of the hostel buildings and physical dimensions of the hostel rooms in the study area
2. examine the adequacies of IEQ components of thermal comfort, IAQ, lighting and acoustic using the parameters of Window to Floor Area Ratio, Window to Wall Area Ratio and Indoor Ventilation rates in the study area.
3. investigate the satisfaction of the students with the Indoor Environmental conditions in the hostel rooms of the selected universities.
4. investigate the impact of IEQ conditions on students' wellbeing in the hostel rooms of the selected universities.

## 1.4 Research Questions

1. What are the compass orientation of the hostel buildings and the physical dimensions of the selected hostel rooms in the study area?
2. How adequate are the IEQ components of thermal comfort, IAQ, lighting and acoustic in the selected hostel rooms of the study area?
3. What are the levels of students' satisfaction with the Indoor Environmental conditions in the hostel rooms in the study area?
4. What are the impacts of IEQ conditions on the students' wellbeing in the hostel rooms of the selected universities?

## 1.5 Significance of the Study

This study's findings will help policymakers, built environment experts, and other academic researchers, both locally and globally, to gain a deeper understanding of the requirements for quality indoor environment that may be applicable in the design of naturally ventilated universities' hostel. In addition, this study further enhances knowledge on the influences of indoor conditions on the occupants' overall wellbeing, vis-a-vis its contributing factors in the hostel rooms.

Therefore, to the policymakers, this study provides a framework for a better understanding of IEQ components and its effects on students' wellbeing so as to strengthen a focus to improve and enhance students' productivity in the hostels. The study specifically investigates the IEQ of naturally ventilated hostel rooms and its influences on students' wellbeing, so as to ascertain the existing factors/components of indoor environmental quality in the hostels, thus, providing a database for the establishment of knowledge and experiences on the indoor environmental quality effects on students' physical wellbeing in Nigerian Students' dormitories.

To the built-environment professionals, the results of the study can provide useful guidelines in the design of future hostels that will be responsive to IEQ needs to ensure occupants' wellbeing and productivity. This study is also intended to assess the influence of quality of hostel indoor environment on students' wellbeing with a bid to enhance planned and optimized improved environment and comfort for the students. This study is thus, to promote a balance between IEQ conditions and occupants' comfort, satisfaction, wellbeing & productivity in the hostels. Also, the study will be useful to yield insights that necessitate organizational and spatial transformations in the future hostel designs. This will follow the most recent developments in dormitory design, which emphasize comfort, satisfaction, pleasure and wellbeing in order to support students' wellbeing in the hostel rooms.

This work will be useful to other researchers, to offer a basic database for subsequent pursuing deeper exploration into the influence of IEQ on students' wellbeing as a database source. Moreover, students in hostels represented a large population of people in any one building at any time and therefore expected to affect a large mass of the population in return. Summarily, findings inferred that hostels are not performing up to the acceptable global comfort standards[17, 21]. Hence, this study is useful to provide deeper understanding on how acceptable and satisfactory quality of indoor ambience is inclined on an enhanced/improved occupants' mood, productivity and wellbeing in any building.

## 1.6 Scope of the Study

This study's scope is focused on the evaluation of hostel rooms' Indoor Environmental Quality (IEQ) and its effects on students' wellbeing in only four (4) selected universities in Oyo state, Nigeria. Therefore, selected Universities possessing purposely built students' hostels were considered. These are the University of Ibadan, Abiola Ajimobi Technical University, Ajayi Crowther University and Lead City University students' hostels (Table 3.1).

Also, this study is focused only on the assessment of physical dimensions of hostel rooms' layout and administration of questionnaires to obtain information on the students'satisfaction with the Indoor Environmental Quality (IEQ) conditions of hostel rooms.

## 1.7 Limitation of the Study

This study is restricted to the adoption of both physical measurement of hostel rooms' layout and students' appraisal of IEQ components through the administration of survey questionnaires to extract information on the hostel rooms' indoor environmental quality (IEQ) component and influences of these components on students' wellbeing in selected universities. However, the adoption of experimental/climatic measuring equipment is not applicable in this study due its unavailability and financial constraints. Due to the same limitation, only four (4) universities hostels were selected as representatives for the course of this study. This enhances saving of time and cost.

## 1.8 Operational Definitions of Terms

**Acoustic:** This is a phrase used to describe the characteristics that dictate a room's capacity to reflect sound waves in a way that creates distinctly different hearing. In terms of sound generation, effects, rules, transmission, and reception, it also refers to a science of sound.

**Hostel:** It is an important facility provided on any conventional academic institution to serve students' housing needs or a communal facility and shared space with limited access that helps build students' intellectual capacity and enhances students' productivity and wellbein.

**Indoor Air Quality:** It refers to the quality of air velocity/movement within and around buildings/structures, especially as it corresponds to the building residents' health, comfort, performance and wellbeing.

**Indoor Environmental Quality:** This pertains to the permissible thresholds for Indoor Air Quality, Thermal, Visual, and Acoustic Comforts. It can also refer to the quality of building's environment as it relates to the productivity and well-being of its residents.

**Lighting/Visual:** It is the deliberate use of light to achieve practical and aesthetic effects. Lighting comprised the use of both natural illumination through capturing of daylight together with artificial light sources.

**Productivity:** It is described as a measure of how efficiently a person/worker completes a job. It is commonly measured in output per worker or output per worker per hour.

**Sustainability:** It is defined as the practice and ability to maintain healthy and comfortable indoor environments in the strategies to minimize environmental impacts, enhancing wellbeing and ensuring economic viability in the course of meeting the present needs without compromising the future ability to meet its needs.

**Thermal Comfort:** It is a mindset condition that articulates sensory and stress-free pleasure with the thermal situation of the environment or a comfortable condition where an occupant is neither feeling too hot nor too cold, subjectively assessed by the users of the building.

**Well-being:** This is a positive and fulfilling state of being that encompasses physical aspects of an individual's life. It involves experiencing pleasure, satisfaction and happiness, as well as having a sense of purpose, meaning, and connection to others. Furthermore, it is not just the absence of illness or stress but a dynamic and ongoing process of growth, development and flourishing.

## Endnotes


1. P. Amoatey, K. Al-Jabri, S. Al-Saadi, I. Al-Harthy & M. Al-Khuzairi, "*Impact of Indoor Environmental Quality on Students' Comfort in High School Buildings during the Summer Season in an Extreme Climate,"* **Journal of Architectural Engineering***,* 29, 3, 2023: 04023014.

2. M. Piasecki, E. Radziszewska-Zielina, P. Czerski, M. Fedorczak-Cisak, M. Zielina, P. Krzyściak, P. Kwaśniewska-Sip & W. Grześkowiak, "*Implementation of the Indoor Environmental Quality (IEQ) Model for the Assessment of a Retrofitted Historical Masonry Building",* **Energies***,* 13, 22, 2020: 6051.

3. H.S. Abdulaali, I. Usman, M. Hanafiah, M. Abdulhasan, M. Hamzah & A. Nazal, "*Impact of Poor Indoor Environmental Quality (IEQ) to Inhabitants' Health, Wellbeing and Satisfaction,"* **International Journal of Advanced Science and Technology***,* 29, 3, 2020: 1-14.

4. F. El Zein & R. Hijazi, "*Poor Indoor Environmental Quality leading to Sick Building Syndrome*," **International Journal of Multidisciplinary and Current Educational Research (IJMCER)***,* 3, 6, 2021: 158-165.

5. T. Waseem & F. Aslam, "*Educational Learning Theories & their Implications in Modern Instructional Designs*," **Health Professions Educator Journal***,* 3, 2, 2020: 25-31.

6. A.O. Afolabi, A. Arome & T.F. Akinbo, "*Empirical Study on Sick Building Syndrome from Indoor Pollution in Nigeria,"* **Journal of Medical Sciences**, 8, 2020: 395-404.

7. P. Aparicio-Ruiz, E. Barbadilla-Martín, J. Guadix & J. Munuzuri, "*A Field Study on Adaptive Thermal Comfort in Spanish Primary Classrooms during Summer Season,"* **Building and Environment,** 203, 2021: 1-14. doi:https://doi.org/10.1016/j.buildenv.2021.108089

8. T.D. Mustapha, A.S. Hassan, F. Khozaei & H.O. Onubi, "*Examining Thermal Comfort Levels and ASHRAE Standard-55 Applicability: A Case Study of Free-running Classrooms in Abuja, Nigeria*," **Indoor and Built Environment** 33, 1, 2024: 8-22.

9. J. Khan, T. Hussain, M.T. Javed & S. Meraj, "*Effect of Indoor Environmental Quality on Human Comfort and Performance: A Review,"* **Ergonomics for Improved Productivity: Proceedings of HWWE 2017***,* 2, 2022: 335-345.

10. C. Kakoulli, A. Kyriacou & M.P. Michaelides, "*A Review of Field Measurement Studies on Thermal Comfort, Indoor Air Quality and Virus Risk,"* **Atmosphere***,* 13, 2, 2022: 191.

11. D.O. Nduka, K.D. Oyeyemi, O.M. Olofinnade, A.N. Ede & C. Worgwu, "*Relationship between Indoor Environmental Quality and Sick Building Syndrome: A Case Study of Selected Student's Hostels in South-Western Nigeria*," ***Cogent Social Sciences****,* 7, 1, 2021: 1-17.

[12.] M. Pulimeno, P. Piscitelli, S. Colazzo, A. Colao & A. Miani, "*Indoor Air Quality at School and Students' Performance: Recommendations of the UNESCO Chair on Health Education and Sustainable Development & the Italian Society of Environmental Medicine (SIMA),"* **Health Promotion Perspectives**, 10, 3, 2020: 169.

[13.] F. Quesada-Molina & S. Astudillo-Cordero, "*Indoor Environmental Quality Assessment Model for Houses,"* **Sustainability**, 15, 1276, 2023: 1-18.

[14.] G. Lamberti, G. Salvadori, F. Leccese, F. Fantozzi & P.M. Bluyssen, "*Advancement on Thermal Comfort in Educational Buildings: Current Issues and Way Forward,"* **Sustainability**, 13, 18, 2021: 10315.

[15.] B.A. Orola, "*Seasonal Variations in Indoor Air Quality Parameters and Occupants Self-Reported Physical Health within a Warm Humid Climatic Environment*," **Sustainable Buildings**, 5, 2, 2020: 1-30.

[16.] C. Yadeta, M. Indraganti, E. Alemayehu & G.T. Tucho, "*An Investigation of Human Thermal Comfort and Adaptation in Naturally Ventilated Residential Buildings and its Implication for Energy Use in Tropical Climates of Ethiopia,"* **Science and Technology for the Built Environment**, 28, 7, 2022: 896-915.

[17.] H. Njoku, O. Odugu & N. Chibuike, "*Investigation of Indoor Thermal Comfort and Air Quality in Typical Student Residences,"* Proceed-ings Paper, 3, 2021.

[18.] I. Madhavi, K. Farsana, A. Reem, A. Lulwa, A. Saeeda & A.A. Maryam, "*Occupant Perception of Thermal Comfort in Sleep Environments in Qatar,"* **The Journal of Engineering Research (TJER),** 18, 2, 2021: 137-145.

[19.] I.L. Niza, M.P. de Souza, I.M. da Luz & E.E. Broday, "*Sick Building Syndrome and its Impacts on Health, Well-being and Productivity: A systematic Literature Review*," **Indoor and Built Environment**, 33, 2, 2024: 218-236.

[20.] H.W. Brink, W.P. Krijnen, M.G. Loomans, M.P. Mobach & H.S. Kort, "*Positive Effects of Indoor Environmental Conditions on Students and their Performance in Higher Education Classrooms: A Between-groups Experiment*," **Science of the Total Environment,** 869, 2023: 161813.

[21.] M. Jowkar, H.B., Rijal, A. Montazami, J. Brusey & A. Temeljotov-Salaj, "*The Influence of Acclimatization, Age and Gender-related Differences on Thermal Perception in University Buildings: Case Studies in Scotland and England,"* **Building and Environment**, 2020.

[22.] H. Tang, Y. Ding & B.C. Singer, "*Post-occupancy Evaluation of Indoor Environmental Quality in Ten Non-Residential Buildings in Chongqing, China,"* **Journal of Building Engineering**, 32, 2020: 101-649. https://doi.org/10.1016/j.jobe.2020.101649

[23.] J. Hu, N. Li, S. Zou, H. Yoshino, U. Yanagi, C.W. Yu & H. Qu, "*Indoor Environmental Conditions in School Children's Homes in Central-South China*," **Indoor and Built Environment**, 29, 7, 2020: 956-971.

24. J. Woo, P. Rajagopalan, M. Francis & P. Garnawat, "*An Indoor Environmental Quality Assessment of Office Spaces at an Urban Australian University*," **Building Research & Information**, 49, 8, 2021: 842-858.

25. N. Farrag, M.A. Abou El-Ela & S. Ezzeldin, "*Sick Building Syndrome and Office Space Design in Cairo, Egypt,"* **Indoor and Built Environment**, 31, 2, 2022: 568-577.

26. M.U. Adaji, T. Adekunle & R. Watkins, "*Overheating and Passive Cooling Interventions on Low-Income Residential Houses in Abuja, Nigeria,"* Proceedings of the 11th Windsor Conference, Cumberland Lodge, Windsor, UK 16th-19th April. 2020.

27. T. Sikram, M. Ichinose & R. Sasaki, "*Assessment of Thermal Comfort and Building-Related Symptoms in Air-Conditioned Offices in Tropical Regions: A Case Study in Singapore and Thailand*," **Frontiers in Built Environment**, 6, 2020: 567787.

28. I. Sakellaris, D. Saraga, C. Mandin, Y. de Kluizenaar, S. Fossati, A. Spinazzè, A. Cattaneo, V. Mihucz, T. Szigeti, E. de Oliveira Fernandes & K. Kalimeri, "*Association of Subjective Health Symptoms with Indoor Air Quality in European Office Buildings: The OFFICAIR Project*," **Indoor Air**, 31, 2, 2021: 426-439.

29. A.M. Sadick, Z.E. Kpamma & S. Agyefi-Mensah, "*Impact of Indoor Environmental Quality on Job Satisfaction and Self-reported Productivity of University Employees in a Tropical African Climate*," **Building and Environment**, 181, 2020: 107-102.

30. W. P. Akanmu, S. S. Nunayon & U. C. Eboson, "*Indoor Environmental Quality (IEQ) Assessment of Nigerian University Libraries: A pilot Study,"* ***Energy and Built Environment***, 2, 3, 2021: 302–314. https://doi.org/10. 1016/j.enbenv.2020.07.004

31. D. Wang, C. Song, Y. Wang, Y. Xu, Y. Liu & J. Liu, "*Experimental Investigation of the Potential Influence of Indoor Air Velocity on Students' Learning Performance in Summer Conditions,"* **Energy and Buildings**, 219, 2020: 110015.

32. P. Wargocki, J.A. Porras-Salazar, S. Contreras-Espinoza & W. Bahnfleth, "*The Relationships between Classroom Air Quality and Children's Performance in School*," **Building and Environment**, 173, 106749, 2020: 1-20.

33. J. Hou, Y. Sun, X. Dai, J. Liu, X. Shen, H. Tan, H. Yin, K. Huang, Y. Gao, D. Lai & W. Hong, "*Associations of Indoor Carbon dioxide Concentrations, Air temperature, and Humidity with Perceived Air Quality and Sick Building Syndrome Symptoms in Chinese Homes*," **Indoor Air**, 31, 4, 2021: 1018-1028.

34. Z. Shao, J. Bi, J. Yang & Z. Ma, "*Indoor PM 2.5, Home Environmental Factors and Lifestyles as Related to Sick Building Syndrome among Residents in Nanjing, China,"* **Building and Environment**, 235, 2023: 110204.

# Chapter Two

# Literature Review

This chapter is structured into sections to include the conceptual review of dependent and independent variables, theoretical review of related theories and review of empirical studies of related works. Similarly, due attention is given to conceptual model showing the affiliation between the independent & dependent variables and finalize with the summary of gaps in the reviewed literature.

## 2.1 Conceptual Review

### 2.1.1 Indoor Environmental Quality

Indoor environmental quality (IEQ) is defined as the environmental quality of a building in relation to the health, well-being, learning, satisfaction, motivation, productivity and performance of its occupants within the space[1]. Healthy buildings with quality indoor environment lead to happier inhabitants[2]. Approximately 90% of the occupants' periods are spent indoors, such as hostels, domestic homes, offices, schools, among others[3]. The satisfaction, learning, wellbeing, health and productivity of residents are therefore greatly impacted by the interior environment[4]. Several studies showed that the improvement in IEQ positively affects occupants' wellbeing, health, mood, showing increasing awareness with respect to IEQ and its infuence on the satisfaction, motivation, learning, productivity and performance of occupants. For instance, it was established that IEQ improvement could cause rise in the mood, productivity and performance by 4.8% and diminish sick leave days[5].

In a similar study, it was found as well that improved IEQ led to decrease in absenteeism which may be as an outcome of respiratory allergies, depression, asthma and stress. It leads also to effective working hours and self-reported improvements in wellbeing, learning performance and productivity[6].

However, if indoor environmental quality were the same, occupants can have different perceptions, leading to different subjective responses[7]. It was also established that overall comfort was affected not only by contentment with indoor environmental factors but also by having control over the indoor setting, the amount of privacy, office layout, decoration, and cleanliness[8]. Therefore, to improve comfort with indoor conditions, people need to control the indoor climate through behaviours such as the opening of windows, air-conditioning, and the control of temperature, lighting, and solar shading[7]. As a result, IEQ had a great influence on the energy consumption of any building. Poor indoor environments could cause dizziness, throat irritations, and other health problems, which could lead to decreased occupant satisfaction, motivation, wellbeing, learning performance, and productivity in return[9]. Poor indoor environmental quality may be a risk for occupants' wellbeing. Consequently, unhealthy buildings have been associated with the high occurrence of sick building syndrome symptoms like headaches, dry eyes or throat, itchy eyes, sneezing, blocked and stuffy nose, runny nose, and dry or irritated skin[10]. Furthermore, it was noted that, there was a relationship between poor IEQ conditions and sick building syndrome (SBS), and between good IEQ and improved wellbeing, health, learning motivation, satisfaction, productivity and performance[11]. Poor indoor environmental quality (IEQ) mostly harms vulnerable inhabitants groups such as school children[12].

School buildings such as hostels required more consideration regarding IEQ matters compared to other structures[13]. Over the last decades, several researches were conducted in school buildings to investigate the effects of IEQ, especially in developed countries. It was reported that satisfactory IEQ in school buildings played an essential role in the health, satisfaction, motivation and learning performance of students and school workers[12, 8]. It was expanciated that, the main concerns of environmental problems for schools were high concentrations of carbon dioxide ($CO_2$), insufficient/poor daylight, uncomfortable thermal conditions, and acoustic discomfort[12]. Also, a high frequency of sick building symptoms in school premises were observed and found that a negative association exists between the temperature, humidity, and $CO_2$ levels in the school[14]. Furthermore, an unacceptable environmental condition in building indoors were due to poor ventilation, noise, or lighting that affected the comfort, wellbeing, satisfaction, mood, productivity, health and learning performance of occupants[8]. Moreover, different studies assessing the relationships of various health outcomes among occupants with indoor environmental factors reported that poor indoor environmental quality in the building indoor might result in illness, leading to absenteeism at work, adverse health symptoms, and decreased motivation, satisfaction, learning and productivity.

Indoor environmental quality (IEQ) includes many parameters such as thermal comfort, indoor air quality, ventilation rates, acoustics, ergonomics, and visual comfort that may have an impact on occupants within the building. The four major indoor environmental quality parameters in buildings are thermal Comfort (TC), Indoor Air Quality (IAQ), Acoustic Comfort (AC), and Visual Comfort (VC)[15].

### 2.1.2 Parameters/Components of Indoor Environmental Quality (IEQ)

Providing a good indoor environment is vital for the success of building design, not only because it seeks occupant comfort, but also because it has a substantial effect on health, wellbeing, motivation, satisfaction, productivity, and learning performance. Today's standards that define acceptable indoor environments should address all these factors[16]. The indoor environment can be characterized as active interactions of spatial, social, and physical variables that affect wellbeing, productivity, satisfaction, mood, learning performance, health, and comfort[17]. The comfort condition in an environment is determined by the interplay of physical interactions with physiological, psychological, social, and cultural rights; these factors are influenced by the architecture, clothing, food, and climate[18]. Therefore, the evaluation of Indoor Environmental Quality does not depend only on the human body's physiological and psychological responses, but also on the physical parameters of the environment (i.e. thermal, indoor air quality, acoustics, and lighting).

The human body, through its physiological systems, will respond to the diverse environmental variables through a lively interaction, which can result in successful or unsuccessful response to the outside world. Unsuccessful responses can result in the occupant's death owing to situations that exceed the survivable limitations. As a result, measuring variables of indoor environmental quality (IEQ) has emerged as the primary method for promoting building occupant health, wellbeing, satisfaction, motivation to learning, productivity and performance[19,20]. The identification and application of these parameter/indicators have taken diverse dimensions in different researches. The IEQ components in a building includes acoustic, lighting, thermal comfort and air quality, as well as other elements like environmental safety, health, and building configuration[16]. In a Malaysian study of IEQ in hospital buildings and its effect on the comfort and wellbeing of occupants, 15 criteria and 37 variables were identified as indicators, while other studies found 9 key physical factors[21, 22]. Nonetheless, most IEQ research in buildings have relied solely on thermal, acoustic, lighting, and indoor air quality as the primary criteria in assessing IEQ occupants' wellbeing, health, satisfaction, mood and performance[23, 24]. This primary criteria thus presents a detailed theoretical evaluation of studies that investigated how indoor environmental quality variables influence the students' wellbeing in the dormitories in this study.

#### 2.1.2.1 Thermal Comfort

Thermal comfort is the state of mind that expresses the satisfaction level of the building users with thermal environments in the building indoor. It is also described to be achieved through subjective assessment of 80% thermal acceptability[25]. Thermal comfort has been linked to building users' pleasure, wellbeing, satisfaction, mood/motivation, productivity, and performance in an indoor thermal environment. Therefore, three ways to measure human responses to comfort are thermal sensation, thermal acceptability, and thermal preferences[26]. The perception of a building occupant regarding thermal ambiences is the user's thermal sensation. The level to which a building occupant accepts thermal environments is thermal acceptability while the ideal thermal environment according to the building occupant is the occupant's thermal preference. Thermal comfort is a subjective condition, whereas thermal feeling is an objective state defined as the direction and intensity of a person's sensual feeling of their indoor environment. Thermal sensation is presented on a 7-point scale: Cold (-1), Cool (-2), Slightly Cool (-1), Neutral (0), Slightly Warm (+1), Warm (+2) and Hot (+3)[27, 28].

There are six parameters that influence thermal comfort. Four of the six parameters that determine thermal comfort are environmental (mean radiant temperature, relative humidity, dry bulb temperature, and air speed) while two are personal parameters, notably metabolic rate and clothing[29]. Today, the four localized factors that are further considered in the thermal comfort assessment are: vertical air temperature difference, radiant temperature asymmetry, floor temperature and drafts[30]. Other factors influencing users' perception of thermal feeling include gender, age, race, individual condition, geographic location, cultural effect, nature of job, and climate[31].

Studies highlighted the relationship between ventilation and thermal comfort in a naturally ventilated school building that, most of the users chose an opened window to allow-in fresh air and escape excess heat in the spaces from the open window[31]. Furthermore, a study investigated the effects of thermal environment on teaching and distraction in a naturally ventilated classroom found that unacceptable thermal environments reduce the occupants' wellbeing, motivation, satisfaction, learning, performance and health[32]. However, other studies revealed that having physically warmth can raise the favorable sensations of occupants, potentially increasing the learning performance[31].

Thermal comfort is also dependent on the behavioral adjustment, physiological, and psychological characteristics of the occupant[14]. There are multiple numbers of models, indices, and charts in assessing thermal comfort, such as Predicted Mean Vote (PMV), Resultant Temperature (RT), Effective Temperature(ET), Adaptive Model, Tropical Summer Index (TSI), Heat Stress Index (HSI), Wet-Bulb Globe Temperature (WBGT), Equatorial Comfort Index (ECI), Index of Thermal Stress (ITS), Wind Chill Equivalent Temperature (WCET), Predicted 4 Hour Sweat Rate (P4SR), India Model for Adaptive Comfort (IMAC), Percentage People Dissatisfied (PPD), Humidex, Standard Effective Temperature (SET), Predicted Thermal Sensation (PTS), and the Givoni model, the Mahoney model, and the Olgyay model. Two models are used globally to assess thermal comfort. For example, in air-conditioned buildings, the Predicted Mean Vote and Percentage People Dissatisfied (PMV/PPD) model given by Ole Fanger in 1970 is commonly utilized, whereas the Adaptive model offered by Richard de Dear is used in non-air-conditioned buildings[14].

The Adaptive model is based on real-time field experiments, which show how occupants adapt to the thermal conditions via moveable windows, clothes, sunshades, fans, and so on. Comfort assessment is more precise in an adaptive approach because it takes into account of adaptations during changes in the thermal environment as the human body attempts to maintain its temperature[33]. International Organization for Standardization code ISO 7730 (2005) ISO 7730 (2005) is based on the PMV model. The PMV model has the limitation of being a chamber-method-based study, which is incompatible with natural human interaction with the environment. It forecasts a high level of dissatisfaction due to a lack of personal, cultural, social, and environmental contexts. The Tropical Summer Index (TSI) is a suggested index for determining thermal comfort levels, optimal circumstances, and the range of thermally acceptable surroundings in warm-humid and hot-dry climates[34]. The Standard Effective Temperature (SET) model, often known as the Pierce 2-node model, was developed to characterize the human response to thermal surroundings[30]. The calculation for this model is similar to the PMV model, with the primary difference being that it takes into account human physiology when evaluating skin wetness and temperature. ASHRAE accepted this model in 1996.

However, later research using experimental data revealed that this model underestimates skin wetness while overestimating skin temperature. Occupants living in naturally ventilated buildings enjoy a greater range of comfort temperature than those living in air-conditioned structures. When applying the PMV model in warm and cold environments, the occupants' thermal comfort is over-estimated and under-estimated, respectively. As a result, it was discovered that Fanger's PMV-PPD (Predicted Mean Vote and Predicted Percentage Dissatisfied) adaptive theory model cannot be used to predict indoor climate in naturally ventilated buildings because it fails to accurately predict comfort conditions and over-estimates occupant comfort and dissatisfaction levels[35, 36].

Furthermore, the adaptive approach is based on global field studies comparing indoor comfort temperature to outdoor temperature, resulting in 80% and 90% satisfaction zones. Fanger's Predicted proportion of Dissatisfied (PPD) model provides an equation for calculating the proportion of dissatisfied, similar to PMV. Over 80% of respondents were satisfied with the PPD model's outcome[37]. Draught sensation is caused by increased air flow rate and can have either a good or negative impact on thermal comfort depending on the conditions. Draught sensation in normal conditions can induce localized thermal discontent when influenced by increased air velocity, although it increases comfort in heated situations. The draft model was incorporated in ISO 7730 (2005) and ASHRAE 55 (2010). The draught rating is the percentage of persons that are dissatisfied with the air velocity. Nonetheless, an analytical model for calculating thermal comfort in buildings with centrally controlled HVAC systems was developed. The study used the room's physical factors (air temperature, air flow rate, relative air humidity, globe temperature) along with human variables (level of dressing, activity) to determine the expected mean vote, known as the PMV index[36]. The PMV index is also used for determining the percentage of dissatisfied occupants, or the PPD index, which measures occupants' dissatisfaction rate with room the conditions (too cold / too hot) on a scale of +3, +2, -3, -2 based on the use of Heat balance method and human physiology factors[39].

Few studies have found that a lack of control over the temperature of the environment leads to greater absenteeism, thus reduces performance, productivity, satisfaction and achievement. Increased controls can improve thermal comfort, however, several research revealed that access to such controls does not increase or diminish thermal comfort[40, 41]. A field investigation of 900 subjects in naturally ventilated classrooms in Bangladesh revealed that, students are more adaptable in their behaviour and may readily modify their comfort by opening windows, turning on fans, and adjusting garment levels[42]. The evaluation of thermal environmental conditions and thermal perception at naturally ventilated dormitories of undergraduate students in composite climate revealed that the students were dissatisfied with the hostels' current environmental conditions. However, to restore comfort, they favoured bathing, using a fan/changing the fan speed, wearing thick clothing, and opening windows and doors[43].

Furthermore, during hot periods in a warm-humid climate, the indoor temperature range of the students' lodging exceeded the comfort zone of ASHRAE standard 55. The respondents' adaptive control preferences include opening windows, wearing light clothing, and using electric fans[44]. However, the desire for sustainable thermal comfort cannot be met solely through mechanical ventilation, as natural ventilation is insufficient to ensure appropriate thermal comfort levels for hostel occupants[45]. In the research study of adaptive thermal comfort in naturally ventilated dormitory structures, it was discovered that the external temperature is rather high, which has a significant influence on the increase in indoor thermal conditions. The adaptive thermal behaviours of garment adjustment and increased air velocity were found to be strongly related to indoor temperature[46]. As a result, occupants of naturally ventilated hostels use windows and fans to preserve thermal comfort at higher indoor temperatures through increase in air velocity.

In a thermal comfort adaptation research study conducted in Malasyian naturally ventilated students' residential colleges; there is an association between low ventilation flow and indoor thermal comfort level[47]. This suggested that insufficient ventilation flow was influencing the level of discomfort experienced by hostel inmates. As a result of the amount of heat stress in the dormitory, students are more likely to adjust their behaviour in favour of using a mechanical ventilation system and wearing thinner and more comfortable clothing materials, which will help them reduce heat discomfort throughout the periods of the day. Simulations conducted in student hostels revealed that the indoor thermal environment of the dormitory is extremely unsatisfactory, and students' ability to control the indoor environmental quality of their rooms is a significant factor in determining dormitory comfort and wellbeing [48]. To restore comfort within the hostel's room, the primary adaptive action was found to be turning on the fans, followed by opening external doors and windows[48]. In addition, a follow-up field study on occupant thermal comfort and preferences in naturally ventilated multi-story hostel buildings over two seasons revealed that the inhabitants were primarily thermally dissatisfied with the existing thermal environments[49]. The students' adaptive behaviour includes using ceiling fans and natural ventilation through opening windows and doors for maintaining thermal comfort.

#### 2.1.2.2 Indoor Air Quality

This is regarded as one of the most essential indoor components. However, it is challenging for building occupants to recognize Indoor Air Quality (IAQ) problems in the indoor environment due to its coupled behaviour with multiple variables and dynamic interaction with other components[50]. In the research study of workplace conditions, it was discovered that the majority of the articles detailed reactive measures regarding IAQ, while just a few studies discussed building construction and design to improve IAQ[51]. In addition to indoor sources, outdoor pollution has an impact on indoor air quality. Sick building syndrome (SBS) (which, with time, can progress to building-related illness, BRI) effects on occupants are produced by inadequate IAQ, which has the potential to harm occupants' wellbeing, health, satisfaction, mood and performance. Inadequate ventilation and poor indoor air quality in buildings can lead to sickness and absence, negatively impacting SBS[31].

A research of indoor air quality, thermal comfort, and their effects on students' wellbeing and performance found that higher respiratory disease and asthma are caused by a rise in indoor humidity and organic pollutants[52, 53]. The research studied how modern design options, such as underfloor air diffusers and displacement ventilation, affect indoor air pollution in schools. However, identifying sources of pollution, such as flooring, paint, and classroom equipment, is crucial for improving indoor air quality. These sources have a significant negative impact on students' wellbeing and health thus, raise the risk of respiratory illnesses and asthma[52]. As a result, removing carpets from indoor spaces can improve students' wellbeing, health, satisfaction and triggers performance by potentially reducing the level of physical contaminants. Removing carpets from indoor spaces also improves indoor air quality, reduces headaches, dizziness, and symptoms of SBS, and improves wellbeing, satisfaction, mood and performance. After the carpet is removed, self-assessment revealed that fewer headache incidents are related to improved learning performance.

Indoor air quality represents a combination of outdoor pollutants commonly associated with vehicular traffic and industrial activities, which can penetrate indoors by infiltrations and/or through natural and mechanical ventilation systems, along with indoor contaminants, which originate inside the building, from combustion sources (such as burning fuels, coal, and wood; tobacco products; and candles), emissions from building materials and furnishings, central heating and cooling systems, humidification devices, moisture processes, electronic equipment, household cleaning products, pets, and building occupant behavior (such as smoking, painting, etc.)[54].

Chemicals such as gases (e.g., carbon monoxide, ozone, and radon), volatile organic compounds (VOCs), particulate matter (PM) and fibers, organic and inorganic pollutants, and biological particles such as bacteria, fungi, and pollen can all have an impact on IAQ[55]. In Mediterranean climate, test surface loading caused by organic pollutants in carpets in 80 classrooms was investigated, and it was discovered that 30% of the analyzed classrooms had an unsatisfactory level of insect and fungal allergens[53]. In a comparison of tiled and carpeted classrooms, the former had a higher concentration of aerosol particulate matter, while the latter had a contaminated sink and high surface loading[52]. In a comparable study in New York State, the majority of the participants agreed that the building's indoor air quality were unsatisfactory. Approximately 40% of residents reported a loss in performance or ptoductivity with at least one health symptom such as headaches, allergies, and throat irritation, with dust, mold, paint smells, and other indoor pollutants being the main causes[56]. As a result, when air conditioning is employed, occupants feel more concentrated and comfortable, and the performance of air-conditioned space users improves from 5 to 15%[57].

During the summer, residents are uncomfortable if humidity is not controlled. Humidity regulation is critical for providing an ideal comfortable environment and improving IAQ. Cross-ventilation is primarily responsible for maintaining the indoor environment in naturally ventilated (NV) structures. Air enters through doors, windows, and gaps, and new air fills the room volume while stale air leaves through the opposite side openings (if any). Ventilation flow rates less than 0.152m/s are referred to as "still air"; which is detrimental since the impurities remain suspended in the air and occupants inhaled them, which can be harmful to the occupants' wellbeing, health, causing discomfort/dissatifaction, decline motivation, low productivity and performance[58].

In another dimension, during a controlled investigation in a test laboratory, it was discovered that the participants had greater skin temperatures when windows were closed, and that subjects drank more water during that moment, probably due to increased indoor air pollution[59]. To minimize poor indoor air quality, glare, and overheating later, planners must consider building orientation, shading design, devices, and window position and size throughout the design stage[60]. As a result, temperature and ventilation conditions under the direct control of building occupiers lead to fewer health problems, better performance, wellbeing and satisfaction by up to 6.5%, and lower absence rates. Consequently, more than 900 distinct organic compounds have been found in indoor air at varying amounts, causing a variety of health effects on inhabitants. Each of these pollutants has numerous sources in indoor spaces, as well as different concentrations that are dictated by the space's spatial qualities. These sources include indoor finishing materials, furniture, disinfectants, domestic equipment, and activities carried out in the space[61]. This shows that the quality of indoor air as compared to specified requirements may vary across different types of buildings and climatic locations, and that these variances may be significant enough to produce significantly varying health, satisfaction, mood, productivity, and performance results in occupants.

**2.1.2.3 Visual/Lighting**

Lighting is an essential indoor environmental component of every building. Designers are responsible for selecting acceptable lighting types and layouts with adequate dimensions to provide an optimal lighting environment. Lighting dimensions to consider in buildings include lighting level (illumination and lamination), light transmission and uniformity, and glare control[62]. Conventional building designs are evolving in response to their environmental conditions by manipulating daylighting to boost indoor illumination levels and occupant visual comfort. However, architects must be mindful of defects in daylighting devices that might cause visual discomfort, obstruct vision, increase energy demands, and increase indoor heat gain[63].

In a post-occupancy review of a student hostel in Hong Kong, the student occupants ranked lighting as the third most expected components of indoor environmental quality when compared to the other aspects[56]. However, as compared to other IEQ elements, student occupants are mostly satisfied with the illumination in their hostel rooms. As a result, hostel rooms must be fitted with adequate lighting dimensions. Receiving optimal daylighting quality in conjunction with appropriate artificial lighting dimensions is critical in any building space.

Furthermore, a room with no daylight may impair the building occupant's concentration in doing activities or reduce their work performance, wellbeing, satisfaction and good mood. Inadequate or excessive lighting levels can cause dry eyes, ocular discomfort, allergic reactions, and headaches[64]. Furthermore, lighting has a considerable impact on the psychological and physical health of building residents, as any visual discomfort, such as weariness, dizziness, headache, and migraine, can be produced by excessive brightness for highly sensitive people[62]. The fluorescent light releases a significant amount of ultra-violet (UV) light, which can cause a variety of eye-related health difficulties in extremely sensitive people, including UV-light-induced eye disease[65]. This has a negative impact on the health, wellbeing, comfort, and pleasure of the residents, motivation, as well as their productivity and performance.

On the plus side, appropriate lighting conditions can improve building occupants' vision comfort, attitude and emotion, and focus[88]. In addition, ambient lighting situations may alleviate seasonal anxiety and depression[64]. It may also improve occupant morale, satisfaction, wellbeing, job quality, and productivity[67]. Also a good lighting ambience improves comfort since it allows for optimal job visibility and reduces eye strain. Visual/lighting comfort is critical to motivation, satisfaction, performance, productivity, wellbeing and health[68]. It is also a subjective feeling of visual well-being caused by the lighting environment[31]. Daylighting promotes occupant mood & productivity, reduces stress, and improves the wellbeing and health of the space users. It relates with a building occupant's satisfied attitude, minor eye stain, decreased fatigue, and less errors and flaws in task[31]. There are two types of natural daylighting: side lighting (window opening) and skylights (or any other aperture in the building roof utilized for top lighting[69].

In order to produce a better lighting design, six components were aligned to cover most areas of lighting design, including the incorporation of artificial lighting and natural daylight, so establishing the building's standard maintained illuminance of 300 lux[70]. Similarly, an Android app is being developed for mixing natural daylight with artificial lighting to improve the energy efficiency of residential and commercial buildings during the day under all sky conditions in the United Kingdom. Lightings physical environment has been shown to have an impact on wellbeing, satisfaction, motivation, comfort, and performance[31]. It was discovered that varied perceptions of illumination emerged: some believed that illuminance, colour, and lighting had no effect on them, whereas others said that these aspects had a direct impact on their mood[10]. As a result, variations in mood have a significant impact on the performance of such users. Inadequate lighting can cause a variety of mental and physical impacts, giving the building a low quality impression.

Accordingly, the examination of lighting impacts in classrooms revealed that classrooms must be built to accommodate all conceivable activities at all levels in order to improve psychological benefits[10.] It was suggested that the illumination level, lighting spectral distribution, and design could influence wellbeing, satisfaction and mood, hence, building user performance[70]. Furthermore, bright colours and powerful lighting can improve building occupants' comfort and happiness[71]. In experiments, good lighting control and bright lights have been shown to improve occupants' health, mood, wellbeing, satisfaction and performance[72]. As a consequence, classroom illumination is critical for fostering positive attitudes in both students and teachers, rather than simply focusing light on certain portions of the classroom[73]. A study on the effects of daylight and curtains on lighting in European offices found that employees who can readily adjust natural daylight are more satisfied with good motivation than those workers who cannot. However, the illuminance level is not adequately controlled in respect to the outside lighting level[39]. Thus, window orientation is critical, as well as natural daylight control strategies[74]. The southern part of the building gets more direct sunlight than the northern part. Therefore, to alleviate the glare concerns associated with direct sunlight, southern façade windows require shading devices and more curtains than the northern sides of a building[75].

Similarly, increased or excessive glazing in building façades, as well as poor design, increases glare problems, necessitating the addition of more blinds and shading devices. This reduces natural daylight indoors and gradually elevates the need of artificial light, resulting in excessive energy consumption and higher carbon dioxide emissions[76]. In a study conducted to develop an Android software which incorporates daylight and artificial illumination to enhance building energy efficiency during the day in all climates in India. Natural daylight is preferred over artificial light by building inhabitants due to its stress-reduction, wellbeing and health benefits. Thus, good inclusion of both natural and artificial lights can maximize the building inhabitants' wellbeing, mood, satisfaction, performance and productivity by up to 15% and 20 - 26%, respectively[77]. Also, while determining the energy-saving potential of daylight, the results revealed an 11% - 86% decrease in electricity consumption for lighting[78]. While solar heat gain and daylight glare have negative effects, dynamic lighting and outdoor views have a positive impact on building residents[79].

In the correlation between natural daylight and building users' performance in schools' buildings, the daylighting influences motivation to learning outcomes, health, wellbeing, satisfaction and thus users' productivity[80]. When teachers and students can readily modify their lighting environment, they felt that a more regulated, appropriate level of lighting helps them do better[80]. As a result, for optimal learning outcomes, the entire indoor must have controlled with adequate natural daylight as well as sufficient artificial illumination. Lack of lighting design and control induces symptoms such as eye strain, headaches, fever, and muscular pain[31]. Visuals can have a significant impact on pupils' health, wellbeing, satisfaction, motivation to learning and performance in school. It was stressed that visual impairment is a significant predictor of wellbeing, satisfaction, learning motivation and performance[81]. A series of studies on various grades of primary school in Australia showed that greater visual information processing leads to improved learning performance[82]. Hence, visual performance is a fundamental idea in learning[83].

**2.1.2.4 Acoustic**

Acoustic comfort refers to a building's ability to provide safety measures or safeguards to its residents from surrounding noise disturbances while also providing a better acoustic environment in which they may converse without exerting additional effort. Typically, building occupants have little control over indoor acoustic conditions and sources. People who live in noisy surroundings may experience stress, hypertension, sleep difficulties, irritability, earaches, and other symptoms, as well as becoming more irritated and speak loudly due to their exposure to shouting[84]. Age and receiver conditions also influence hearing and consequently alter occupant perceptions of their surroundings[85]. In a research conducted in German, low-income occupants are more likely to experience acoustic discomfort than high-income occupants[86]. When exposed to noises on a constant basis, occupants may experience concentration problems and other mental health issues.

Acoustic comfort has a direct impact on inhabitants' health, wellbeing, motivation, comfort, satisfaction, productivity, and performance[87]. Poor acoustics lead to worse students' performance, reduced concentration & worsens wellbeing, causing fatigue in listeners, and poor conversation quality[88, 89]. As a result, users have a tough time disregarding unpleasant sounds and background noises. An appropriate acoustic condition can filter or prevent outdoor noise from entering the indoor environment. Noise sources can come from both indoor and outdoor environments, and the distance from the source of noise influences the amount of indoor noise[90].

Research has focused on the impact of noise and poor acoustics on students and teachers for over four decades. The study found that a poor acoustic environment had a negative impact on teaching, learning, motivation and instructors' health[91]. Further study into building acoustics showed that noise exposure can have an impact on inhabitants' health, wellbeing, satisfaction, mood, performance and productivity[56]. Long-term exposure to noise levels over the comfort zone might result in hearing difficulties or permanent damage. Building occupants are bothered by noise levels that exceed their comfort threshold, which can result in a long-term unpleasant acoustical environment that affects their ability to hear[92]. Noise pollution also has an impact on building inhabitants' psychological well-being by reducing personal motivation and efficiency when executing a duty, resulting in decreased productivity[93]. Furthermore, noise pollution and excessive noise can have an impact on people's psychosocial interactions, work performance, and cause health issues such as high blood pressure and hearing loss for building occupants[67].

Further research found that poor indoor acoustic conditions had a negative impact on building inhabitants' communication and interaction abilities, hence lowering their everyday work performance[94]. Acoustical control, particularly prolonged noise exposure, has been shown to impair cognitive functioning and damage pre-reading and reading skills[94]. In relation to the study of student hostels as their primary purpose in providing lodging to students in Malaysia's public universities, it is critical to provide students with a quiet, serene, and restful environment, particularly at night[56]. Though, it is assumed that all students will sleep between 11 p.m. and 7 a.m. the next day, but the reality is far from it. Students' sleep hours vary by individual since they engaged in a variety of daily activities, whether personal, curricular, or academic driven activities. As a result, it has become essential and obligatory to manage noise and improve the acoustical conditions of student hostel indoor spaces[56]. This noise pollution can be reduced and controlled by implementing interior design methods such as spatial design, room form, sound-absorbing materials, and the location of electrical appliances such as air-conditioning units[67]. The study of occupancy comfort in a Malaysian multi-story students' hostel aimed at examining students' responses to the hostel's indoor acoustic comfort level (noiseless or noisy) and their adaptive behavior was conducted. It was established that hostel inhabitants can adapt to any noise level occuring in the indoor area as long as it is modest and falls within their satisfactory and comfortable levels[95].

### 2.1.3 Influence of IEQ on Sick Building Syndrome (SBS)

Acceptable and satisfactory indoor environmental quality (IEQ) is an essential factor for the inhabitants to perform and be productive indoors, as it lowers sick building syndrome (SBS) and minimizes short-term absenteeism[96]. However, building and health sciences research has linked poor indoor conditions to the growth of SBS in buildings around the world[97]. For example, recent research in China had found that a poor rate of ventilation is to blame for the greater concentrations of formaldehyde and volatile organic compounds in household homes[98]. It is also found accountable for financial losses in commercial buildings in the United Kingdom and the United States of America due to large numbers of workers being affected with sick building syndrome. This lowers workers' productivity and wellbeing[99].

In the same vein, previous research identified indoor air pollutants as important contributors to Sick Building Syndrome symptoms in occupied spaces. Therefore, establishing a suitable indoor environment could be a promising strategy of protecting occupants from exposure to preventable illnesses such as sick building syndrome (SBS), resulting in improved occupants' wellbeing, satisfaction, moods, performance and productivity[100]. Sick Building Syndrome (SBS) is an environmental phenomenon as described by the World Health Organization (WHO) in the 1980s[101]. It is used to describe situations in which building occupants experience a range of common symptoms that cause them to feel unwell more frequently than expected, resulting in discomfort & dissatisfaction with decreased motivation, productivity and performance that appear to be linked to the time spent in a building, but with no specific identifiable illnesses[102]. Skin irritation, eye irritation, upper respiratory symptoms, lower respiratory symptoms, and general or non-specific symptoms are the five major groups of symptoms described by the term SBS[103].

Previous study has shown that temperature plays a major role in regulating body conditions such as metabolism, oxygen consumption, and blood pressure. When the air temperature in a room fails to meet health requirements, a person's body loses heat and attempts to balance it with the ambient temperature via the evaporation process. When the room temperature rises, the high temperature merges with the emitted body heat, making the body feel uncomfortable. Conversely, if the room temperature is too low, the blood vessels stiffen, limiting body movement[29]. Light was also identified as a risk factor for the development of SBS in workers[98]. Poor illumination of light has been linked to symptoms such as eye discomfort, tiredness, and headaches. Other research indicates that insufficient or incorrect lighting can cause eye fatigue. Persistent eye fatigue can cause eye health issues and decreased motivation, wellbeing and learning performance[97].

Furthermore, the study found that, humidity has a substantial association with SBS symptoms among employees. High humidity can allow germs and fungi to proliferate, resulting in skin disorders and respiratory difficulties. Low humidity, on the other hand, can cause skin to dry out and wrinkle more easily, as well as chapped lips[104]. The most suitable and healthy working environment is with a relative humidity of 40% - 50%. These conditions additionally provide for a lower incidence of respiratory infections along with faster flu recovery[105]. When the relative humidity exceeded 60%, symptoms such as eye irritation, fatigue, and sneezing developed. Bacteria can grow in relative humidity levels below 30% and above 60%, while viruses may grow in relative humidity levels between 50% and 70%[106]. Bacteria, viruses, and other microbes can create health issues by triggering the body's response to foreign matter.

Ventilation has an important role in the development of SBS symptoms. According to the findings of a study, inadequate ventilation control was linked to an increased risk of SBS in staff [107]. Inadequate ventilation affects air distribution and the availability of fresh air. The presence of ventilation is required to control the airflow rate. Airflow velocity influences air movement and change in the room. The lower the airflow speed, the fewer pollutants will move through the rooms, causing polluted air to settle in the ventilation and be inhaled by the body[108]. In addition, the study found a substantial link between noise and SBS complaints. Noise impairment was found to have a substantial link with SBS complaints, with workers reporting the highest complaints about eye issues and general symptoms. As a result, excessive noise can create a sense of unease, as well as hearing loss thereby decreased performance and productivity[104].

### 2.1.4 Contributions of Indoor Environmental Quality Components on Wellbeing

Recent research has found that indoor environmental quality components have a wide range of substantial effects on inhabitants' wellbeing, satisfaction, motivation, productivity and performance in a variety of dimensions within the building[107]. These were discussed as follows:

#### 2.1.4.1 Thermal Condition

Thermal comfort has a substantial impact on the building occupants' health, satisfaction, wellbeing, productivity, concentration, motivation and performance. Some research found a link between workplace occupants' health, satisfaction and performance and their thermal comfort[109, 110]. When an environment is changed to a preferred thermal state, workers' satisfaction, mood, wellbeing, productivity and performance improved[110]. However, workers' discomfort with thermal comfort may lead to decreased productivity[109].

According to American Society of Heating, Refrigerating and Air-Conditioning Engineer (ASHRAE), indoor relative humidity between 30-60% permits occupants to perform properly[111]. To avoid mold formation, the Environmental Protection Agency (EPA) recommends maintaining a constant indoor relative humidity. Most health impacts become more severe as Relative Humidity values exceed 60% or fall below 40%[112]. However, it is quite beneficial to control humidity in the building. Unfortunately, Heat, Ventilation, and Air Conditioning (HVAC) systems are ineffective at managing space humidity[113]. Relative humidity values less than 30% have a negative impact on occupants' wellbeing, performance, resulting in sick building syndrome. If the air is excessively dry, it can cause respiratory difficulties as well as skin and eye irritation. Building occupants may experience extraordinarily high or extremely low humidity, depending on the time of year, and both have been associated with detrimental health effects, dissatisfaction, decline motivation, lower productivity and performance[114]. Low relative humidity may cause dry and skin irritation, and mucosal membranes, thereby stimulating viral infection[115, 116]. Relative humidity levels lesser than 50% promote influenza virus propagation, whereas excessive dampness is responsible for asthma aggravation, coughing, wheezing, bronchitis, and upper respiratory infections[110].

Likewise, ten-year-old children were exposed to three distinct classroom temperatures of 20°C, 27°C, and 30°C during two hours, while another group of 11-12-year-old children were equally exposed to 20°C in two classrooms and 30°C in another two classes both in the morning and afternoon. The pupils completed mathematics and reading exercises to determine their speed of work and number of errors. The children's performance was significantly worse at higher temperatures of 27°C and 30°C compared to those at 20°C. The children's reading speed decreased and they worked slower on numerical activities in classes with greater temperatures. The detrimental effects of increasing classroom temperatures were more pronounced in the afternoon than in the morning, which is assumed to be linked to fatigue[117, 118].

In a related study of classroom in Danish, temperature was gradually reduced from 25°C to 20°C. Children aged 10 to 12 were given mathematics and reading tasks to test their speed and accuracy. As temperatures dropped from 25°C to 20°C, children's average task performance increased by about 2% for every 18°C drop in temperature[117, 118]. However, variations in temperature had no detectable effect on the amount of normalized errors. Another study on the comfort of secondary school buildings in Cyprus compared reported learning performance in air-conditioned and fan-assisted naturally ventilated conditions. The study discovered that students with uncomfortable thermal sensations reported lower perceived learning performance in fan-assisted naturally ventilated rooms than in air-conditioned environments[119].

Many studies have looked into the temperature range that correlates with enhanced learning. It was reported that the best temperature range for learning is between 22°C and 25°C[119, 120]. The investigation on the effects of temperature on student learning indicated that male undergraduates fared best in a word association test in a classroom with a temperature of 22°C. They performed much worse when temperatures became extreme in either direction[118]. These research concurred that increasing the temperature above 25°C has a negative impact on students' learning, wellbeing, motivation, satisfaction and task performance, whereas lower temperatures boost learning motivation, wellbeing, satisfaction and performance. However, these investigations failed to prove whether very low temperatures could impair learning performance.

**2.1.4.2 Indoor Air Quality (IAQ)**

Indoor air quality (IAQ) issues are associated with health symptoms akin to allergies or colds. These health symptoms are frequently non-specific, rather than clearly recognized illnesses[121]. Typically, building occupants diagnosed with sick building syndrome (SBS) have such symptoms. SBS symptoms include eye, nose, and throat irritation, dryness of mucous membranes and skin, nose-bleeds, skin rash, dry or itchy skin, difficulty breathing or chest tightness, mental tiredness, headache, cough, hoarseness, wheezing, nausea, and dizziness[122]. Sick building syndrome is an ailment characterized by symptoms that appear while inside a certain building but disappear when leaving. The symptoms may worsen or only arise in some zones or rooms.

In a reported Swedish building study, it was discovered that general symptoms like headache, cough, skin itching, dizziness etc were extremely prevalent at high temperatures, and total air bacteria concentration was associated to ocular symptoms. It was also discovered that there is a correlation between observed building dampness and Sick Building Syndrome symptoms[123]. The prevalence of asthma and allergies among building occupants, particularly in schools, has increased in the last decade[124]. Besides the home, school is the most important indoor environment for students[125]. This is highly remarkable due to the fact that individuals with asthma or allergies may be more susceptible to indoor air contaminants[126]. Children may be more susceptible to indoor air pollution than adults. This is related to the increased amount of air inhaled by youngsters relative to their body weight, which results in a higher percentage of pollutant uptake per body weight[127].

All of the investigations in the literature discovered a link between health, satisfaction, wellbeing, mood, productivity and performance. The most significant findings were allergens, asthma, colds and coughs, respiratory infections, nasal patency, and other SBS symptoms. Several studies have linked mold allergies to the presence of molds in the air as well as pollutants in settled dust[53]. It also links coughs and colds to moisture-damaged buildings[5]. Higher amounts of live bacteria and mold increased the likelihood of respiratory infection[53]. Rooms with high amounts of formaldehyde, nitrogen dioxide, and Aspergillum spp. lessened nasal patency (the condition of the nose not being blocked or obstructed[53]. The findings showed that allergy, asthma, hay fever, and eczema are the most common health issues related with perceived poor indoor quality. Air quality, cleanliness levels, dust, shifting room temperatures, smoking, and foul odours have a greater impact on allergic students than non-allergic ones[128]. Lower ventilation rates are associated with deterioration of one or more health or comfort outcomes[129]. According to the research, increasing ventilation rates are associated with a lower incidence levels of SBS, and SBS symptoms have been observed to diminish (reduce $CO_2$) with improved comfort, wellbeing, satisfaction, mood and performance or productivity[130].

According to ASHRAE 62.1 and 62.2, uncomfortable environment caused by the poor indoor air quality can affect occupants, resulting in symptoms such as sneezing, eye irritation, or yawning. However, excellent IAQ have been linked to optimal rate of ventilation[131]. Thus, it was recognized that human beings are not the exclusive source of pollutants/contaminants in the indoor/environments but poor indoor air quality[132]. Indoor air pollution in the workplace, home, or school can cause inflammatory or allergic responses, thereby affecting endocrine function and causing occupants' discomfort in the spaces [133].

In Denmark, an intervention experiment found that increasing classroom ventilation rates improved students' satisfaction, wellbeing, comfort and learning performance. Another study to measure IEQ in a National School Property Portfolio in Wellington indicated that increasing the outdoor air supply rate from 5.2 to 9.6 m/s per person caused an increase in the rate of indoor ventilation thus promoting the students' test performance[118]. This showed that air temperature, humidity, and air flow are essential variables in determining IAQ in a building (relative humidity affects air temperature, while indoor air, outdoor humidity and surface temperatures, all influencing moisture accumulation within a building envelope). A study in Sweden compared a naturally ventilated primary school to a mechanically ventilated school thus, discovered a high level of indoor contaminants in the air of a mechanically ventilated school (respirable dust, bacteria, mould, and VOCs) caused by insufficient outdoor air supply, which was 2-8 times higher in the naturally ventilated school[134]. This otherwise stated that naturally ventilated classrooms required an appropriate flow of outdoor air[134]. Insufficient outdoor air supply may result in air pollutants within the indoor environment, which may cause health problems and negatively impact satisfaction, comfort, learning motivation and performance.

In a study conducted in England to investigate the effects of classroom ventilation on pupil performance and learning, the results revealed that greater ventilation rates of flow had a more precise and faster response for word recognition, picture memory, colour recognition, and choice reaction[135]. This study supports the assumption that greater ventilation rates can improve comfort, wellbeing, satisfaction, motivation and performance, which is best achieved in naturally ventilated classrooms with an appropriate flow of outdoors air supply. In the identical manner as air movement, relative humidity, and air temperature influence the overall condition of indoor air, however, the amount of contaminants that may cause health problems can be used to assess excellent air quality. Inorganic substances (carbon monoxide, sulfur dioxide, nitrogen oxides, carbon dioxide, sand, and so on), organic compounds (urea, formaldehyde foam insulation, and so on), particulate matter (sprays, mist, and dust, and so on), and biological contaminants are the most common types of pollutants[136]. Particulate matter can cause respiratory problems such as coughing, sneezing, dry eyes, throat, nose, and skin irritation, as well as contact lens issues. Classrooms generally have a higher concentration of particulate matter than offices because students engage in more indoor activities and can readily carry particles on their shoes[53]. Biological pollutants can actively thrive in classrooms that have poor IAQ[10]. Fungi also thrive in environments with high humidity, water, or dampness. These contaminants become airborne, resulting in ailments such as respiratory disorders, allergy and asthma attacks[135]. It was further discovered that 83% of classrooms in the study region had bacteria quantities similar or higher than those observed in water treatment plants[118].

Finally, a study conducted in Greece discovered that a 17% rise in indoor $CO_2$ concentration reduces students' learning, wellbeing, performance and satisfaction by 16%[53]. This finding revealed a negative association between students' achieved scores and $CO_2$ concentrations, as well as a positive correlation between their scores with ventilation rates. According to the studies that have been published on the relationship between IAQ and learning performance, poor air quality has a considerable impact on students' wellbeing, satisfaction, learning motivation and performance. As a result, it was demonstrated that IAQ problems in classrooms provide an additional health risk and appear to be the primary IEQ variable that leads to health problems and lowers learning performance[118].

**2.1.4.3 Acoustic/Noise**

Acoustics is concerned with sound and how it influences the learning process. However, noise refers to anything that obstructs the learning process. Noise destabilizes understanding, writing, reading skills, and learning performance in the long run by reducing concentration and relevance to the task[137]. As a component of IEQ, it was determined that noise has negative impact on both psychological and physical well-being. From a large number of proven effects, the following negative outcomes were accounted for, particularly in a noisy room: fatigue, resulting in decreased efficiency; increased heart rate; loss of appetite; sleep deprivation, i.e. insomnia; headaches; tinnitus; dyspepsia; and facial pallor[137]. During school hours, learners are exposed to a variety of noises, ranging from environmental to classroom noises. It demonstrates that noise has a negative impact on students' learning motivation, satisfaction, wellbeing and performance in school. Noise is a constant determinant of human performance[138].

In a study to highlight some of the negative effects of working in a noisy workplace, with a focus on youngsters, it was found that noise had an impact on residents' health as well as their wellbeing, satisfaction, mood, productivity and performance[139]. Apart from noise produced by poorly maintained equipment, an important problem is an intrusive noise from surrounding classrooms, reducing voice clarity, privacy, and causing dissatisfaction and distraction among learners as well as teachers during lecture delivery, thereby having a negative impact on student learning outcomes[137]. Students who frequently forget the content of lectures due to poor indoor acoustics are more likely to perform poorly in school. The noise level is another key consideration that has an acoustical impact on pupils' learning performance. A subsequent study revealed that noise in the classroom was a substantial cause of distraction and disruption for both teachers and students[137]. Poor acoustic characteristics of educational buildings allow outdoor noises to be transmitted into classroom, which is more probable to result in decreased students' satisfaction, wellbeing, learning motivation, hence, performance[140]. Many studies supported the concept that poor acoustic features in the classroom can produce a detrimental learning environment for many learners. As an illustration, a research was done to compare reading test performance of students in two schools using demographic information. One of the schools under consideration was in a quiet neighborhood, while the other was in the flight path of a major airport. The study indicated that students in the fly path school were reportedly distracted, dissatisfied, less motivated and performed poorer than those in the quiet neighbourhood school [118].

In Sweden, pre-recorded noises of airplanes, road traffic, trains, or speech have been compared with quiet conditions in an experimental demonstration involving 12 to 14-year-olds. The reading comprehension test revealed that pupils were scored much worse when exposed to airplane or road traffic noise compared to quiet conditions. Noise from trains[141] wasn't interfering with reading comprehension. Noise levels in schools and classrooms are a major problem for teachers. Another study discovered that instructors' beliefs are based on the reality that noise affects learning performance and creates more discomfort, resulting in worse teacher efficiency than for students[142]. Poor acoustic properties have the ability to impact the quality of teaching, learning and ultimately, performance. Tutors proved to be more concerned about excessive noise levels because it disrupts teaching communication, increases discomfort, and negatively affects students' wellbeing and performance [118].

**2.1.4.4 Visual/Daylighting**

Lighting and colour are visual variables that have an impact on the learning performance of the students'. Colour is a human visual recognition attribute that is defined by colour classes and names. This colour perception results from the stimulation of cone cells in the human eye by electromagnetic radiation in the light spectrum. Colour arrangements and physical representations of colour are linked to objects through the wavelength of light reflected from them. According to the Dictionary of Architecture and Building Construction, it is the visual perception of rays, as well as the transmission and reflection of light from one or more regions of the visible spectrum on the human eye[137].

Colour is a form of visual stimulation in the design studio's physical environment, implying that colour shares certain similarities with psychology in terms of arousal level. When colour is perceived, it causes pleasure and activity. It has been shown that when a person looks at a particular colour or imagines a colour, certain reactions occur in their mind. Depending on the individual's age, different colours produce diverse stimulations in the humans' mind. The colour of the surrounding environment influenced performance on other tasking assignments, such as the reading task. Further research revealed that students performed poorly in both academic and psychological challenging tasks in classrooms with red walls. To fully appreciate the colour of a space, some level of sufficient light illumination is required.

Lighting, among other factors that comprise the design of spaces, is a critical and necessary factor in creating spaces within a building, particularly those for learning. Nonetheless, there are several types of lighting, ranging from natural daylight to artificial lighting. According to study, for lighting to be highly appropriate, day-lighting must be supplemented with artificial lighting, such as electric bulbs that dim in response to daylight level [159]. Similarly, light illumination in a learning environment could only be achieved through the use of both direct and indirect lighting[137]. Light is critical to the overall well-being of those who utilize a physical facility for a considerable portion of their day. Lighting is sometimes overlooked, yet it has an important part in improving environments for functionality and wellness[137]. To improve productivity with lighting, it emphasizes the necessity of smart lighting at educational facility workstations. Just as a workstation pattern works best when it is integrated into the building structure, developing and designing a lighting scheme that is linked to the space plan and functional organization will result in improved lighting system and overall environmental performance[137]. It concluded that the small parts of the users' workspace can have a significant impact on the occupants' academic achievement.



When scores from tests of students were compared across daylight and non-daylight schools, learners in daylight schools were satisfied, motivated and out-performed their non-daylight counterparts by 5-14% [143]. Similarly, a study found a link between high-quality daylight and increased students' satisfaction, wellbeing, motivation and performance in classrooms. According to the data, students in classrooms with the greatest daylight received 7 to 8% higher test scores than those in classes with the least[144]. Furthermore, throughout the investigated school year, classrooms with greater amounts of day-lighting had 26% faster learning performance in reading tests and 20% in mathematics test scores than classes with the least amount of day-lighting[145]. Also, the effects of daylight in schools may benefit students directly by improving their mood or indirectly by improving the mood of teachers. When interviewed, teachers reported that windows and daylight increased their students' learning moods, wellbeing and satisfaction. As a result, the positive effect of daylight on student educational performance improves their attention to learning[146].

A study was conducted to investigate the prospect of generalizing the Heschong Mahone Group findings by replicating the methods in the Zealand setting. The study discovered a link between daylight and improved student test scores and shown that the same process could be replicated in another environment[118]. However, the study revealed that intense sunlight penetration into classrooms could induce glare, which could negatively impact students' satisfaction, wellbeing, mood and performance. However, there is a strong link between good quality daylighting and improved students' wellbeing, satisfaction and performance. Researchers found that daylighting has a good impact on students' learning because it suppresses melatonin in the body. When classrooms receive ample and proper daylight, the production of melatonin is declined, resulting in an increase in alertness, concentration, wellbeing, satisfaction and attention that improve learning performance[118].

### 2.1.5 Influence of IEQ on Occupants' Wellbeing

Well-being is a state whereby an individual occupant realizes his or her own abilities, to cope with the normal stresses of life, work productively, and is able to make a contribution to his or her community[147]. People spent almost nine-tenth of their time in the indoors and these indoor conditions have serious implication for the occupants' general well-being[148]. Several elements such as high-rise living, damp, and noise exposure of the physical environment are related to poor well-being[149]. It was also claimed that a housing environment have physical, social and psychological attributes on the residents' wellbeing[150]. Environmental psychology of human behaviour in a physical environment and architectural space not only has a great impact on creating a friendly and lively environment, but also it can positively affect wellbeing, performance and energize the occupants[151].

In the study of health care facilities, it was observed that, the environmental characteristics influencing wellbeing included thermal condition, indoor air quality, sound and noise, premises and interior design (e.g. construction materials, viewing nature and experiencing nature, windows versus no windows, light, colors, unit layout and placement of the furniture, the type of room, possibilities to control environmental elements, environmental complexity and sensory simulations, cleanliness, ergonomics and accessibility, art) and Indoor environments that incorporate healing elements can reduce anxiety, lower blood pressure, lessen pain and shorten hospital stays[152].

Many studies have established a correlation between indoor environment, asthma and allergies[153, 154]. In the United States, mold and dust are the predominant indoor allergens. In a warm, humid condition, molds developed, produces liquids and gases that causes allergic reactions. This caused 22.2 million people to experience asthma in the United States in 2005. Designing indoor environments may increase or decrease indoor allergens. Humid spaces, high-temperature, visible mold, mold odors and indoor contaminants can foster a condition for growing irritants and allergens[155]. Performance of indoor environmental quality (IEQ) affects the psychological health and wellbeing of inhabitants comprised of symptoms like depression, anxiety and stress, thus affecting inhabitants' confidence, strength and motivation [156, 157]. Studies have shown that natural views accessibility, enhanced ventilation and temperature in the working condition have a positive influence on employees' wellbeing, performance and productivity[158].

Furthermore, in classrooms with the highest daylight exposure, students ' cognitive skills have improved up to 21 percent relative to students with the least daylight penetration[159],[160]. Thus, inhabitants living in good quality indoor environment are physically and psychologically better than inhabitants dwelling in poor indoor environment. It was revealed that, better Indoor Environmental Quality (IEQ) in United States building costing in approximately 6-14 billion dollar per year. However, the workforce saved 1-4 billion dollars from decreased allergies or asthma cases. Such figures reflect improved occupants' wellbeing by regulated ventilation and minimizing issues pertaining to humidity[161].

### 2.1.6 Influence of IEQ on Health

Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity[162]. In addition to physical and mental health, social welfare is promoted as an integral component of overall health, because health is strongly connected to the social environment, working and living conditions. Considering this definition as a global concept, several researchers and theorists successively promoted the adoption of working, practical, and operational interpretations of health. With the endorsement of Health for All by the Year 2000 establshed by theWorld Health Organization (WHO) Global Strategy in 1977, a pragmatic understanding of health (the ability to conduct a socially and economically useful life) was indirectly acknowledged, which was an important goal of the Strategy[163].

Establishing health in functional and effective terms was critical for developing policies and programs to maintain and improve health, and it much exceeded the popularly held belief that health merely means the absence of disease. Moreover, health is generated in the context of daily life and environment, where people live, love, work, and play[164]. Thus, an active and interactive knowledge of health was established. The purpose of promoting health is to merge the approach for addressing the social determinants with the resolution and commitment to inspire and promote people and their neighborhoods to take an active approach to health and adopt healthy lifestyles[165].

Within few decades ago, the WHO definition of health has been increasingly amended and supplemented by the fourth dimension – spiritual health. Within the past few decades, the World Health Organization's definition of health was gradually changed and complemented with the fourth component-spiritual health. Thus, spiritual health includes a sense of happiness and contentment with our own lives, a system of values, self-confidence and self-esteem, self-awareness and presence, peacefulness and tranquility with dynamic emotional balance, both internally and toward the surroundings, morality and truthfulness, selflessness, positive emotions, compassion and willingness to aid and encourage others, responsibility and commitment to the common good, and successful handling of daily life difficulties and expectations, as well as social stress[166].

Various researches revealed that discomfort has a lot of impacts on health of the occupants. Therefore, when the temperature falls below 18$^{o}$C, the potential effect on health rises in severity. The body's reaction to low temperatures results to thickening of the blood, and hypertension and an upsurge risk of cardiovascular or cerebrovascular events[167, 168]. Respiratory stress commences at about 16$^{o}$C and cardiovascular stress when the temperature falls below 12$^{o}$C[169]. As the temperature falls, hypothermia (a drop in the body's core temperature), becomes a reality[170]. Also, low indoor temperatures are often associated with other threats to health such as dampness and mould[171]. However, study revealed a stronger connection between indoor temperature and blood pressure than with outdoor temperature[172]. Exposure to low temperatures has a protracted health impact, with the vast majority of fatalities caused by respiratory and cardiovascular diseases, heart attacks, and strokes[173]. It was further known that an extremely low temperature is attributed to birth abnormalities[174].

In conclusion, exposure to high temperatures can cause a rise in the risk of heat stroke[175] and health havocs such as respiratory, cardiovascular hospitalizations and deaths[169]. High temperatures are strongly linked to a greater risk of still-births and shorter gestation[176]. Unlike cold, the heat-related health effect can result relatively soon after exposure[173]. These health impacts can vary either by region, community or can change over time[177, 178, 179].

### 2.1.7 Students' Hostels

A student hostel is a low-cost, shared lodging facility for students. The hostel lodging aims to keep students within the learning setting, facilitating easy access to academic amenities[180]. It is also described as a dwelling or residence close to workplaces with dual functions of living and private studying[181]. The student hostels encourage social interactions among the students at all levels and enhances a lasting acquaintance[182]. Hostel lodging allows heterogeneous students to gain knowledge from one another, creating interpersonal relationships necessary for human development[183]. Through daily interactions among the peers, the weak learning students improve their understanding ability and become focused as hostel accommodation reduces unfriendly side attractions to learning activity[180]. The hostel accommodations are intended to give not only learning convenience, but also to improve students' behavioural habits required for social interactions and leadership roles.

The provision of hostel rooms allows learners from many different backgrounds and perspectives to interact together, improving their academic and behavioral attitudes[184]. Students' accommodation affects their growth, behaviour, and cognitive performance[185]. A study on the effects of Students' Housing on Academic Performance at the University of Ibadan in Nigeria found that hostel accommodation strengthens academic excellence, particularly among students from low-income backgrounds, by blending this group of students with the brilliant ones, improving students' social value through enhanced interactions, exposing students to resource management, and preparing students for independence and leadership resilience[186].

A student hostel is also known as a dormitory-style housing where students can sleep and relax after daily class review and casual interactions with their classmates. Its purpose is similar to that of a bedroom in one's family home, but with a little difference. As a result, it is critical that the accommodation provides adequate comfort for students to get a good night's sleep and be energized for the next day's learning activities. It is crucial to maintain students' comfort in the hostel room's indoor setting in order to promote sound sleeping habits and enhances optimum wellness in preparation for classroom learning activities. However, most countries, including Nigeria, continue to have ambiguous hostel rooms due to a lack of regular monitoring studies. This is due to the fact that, climate and humans in the building's indoor or outdoor environment have a reciprocal relationship. To promote comfort, a tolerable indoor often has suitable climatic design considerations that are consistent with the outdoor ambient conditions[187]. It is further reported that dormitories in Nigeria, particularly in North-central Federal Universities, are not meeting the needs of students due to the age of the hostel buildings and the annual rise in student population. So, university hostels indoors are in poor condition due to congestion caused by the student population[180].

Though these hostels were conceptualized and designed with standards that met the needs of the generation to which the universities belong, several unfolding technological advancements in academics and the country have rendered the currently existing hostel lodging obsolete and insufficient for the student population. The living areas in these hostels were originally planned for only four (4) users; nevertheless, this space now accommodates many more students than the planned capacity. Due to this congestion, many dormitories are no longer acceptable or satisfying to students by any standard[180]. As a result, there is a need to provide modern and technical facilities in student hostels to improve students' physical health and academic performance. The conducive learning environment improves academic achievement by providing students with good and comfortable living conditions on campuses[188].

**2.1.7.1 Typological Analysis of Students' Hostels**

The typological analysis is a process of reducing the various numbers of students' halls of residence to their basic principles of design and formal structures. This is the morphological approach[189]. There are five types of students' hall of residence based on the typological analysis[190]. These are as follow:

**2.1.7.1.1 Type A:** This typology is structured in the form of a long singled-loading horizontal access or corridor with about ten bedrooms or more served by end located service cores. This type of hall comprises a series of separate linear structures linked at ground level with only one averaged sized social unit per floor. In this typology, due to the larger surface area to volume exposed to external climate, heat gain and loss may be increased and likely prone to noise pollution. It also improves natural lighting and ventilation as it exhibits a single-banked loading[190].

- long horizontal access
- end located service core
- single loading on corridor
- hall comprises a series of separate linear structures linked at ground level only one averaged sized social unit per floor

**Figure 2.1:** Hostel Typology A.

**Source**[190]

**2.1.7.1.2 Type B:** This is a form of students' hostel with short-corridor hall types which had about five bedrooms between the service-cores composed of a singled-loading on horizontal access with three decentralized service cores. Furthermore, the hall is made up of linear structures that are linked together at all levels to form a single, partially enclosed building with three small-sized social units on each floor. In this type of typology, a satisfactory natural lighting and ventilation are best enhanced with effective air circulation due to a single banked and U-shaped geometry[190].

- short horizontal access
- three decentralized service cores
- single loading on horizontal access
- hall comprises linear structures linked together at all levels to form a single and partially enclosed structure
- three small sized social units per floor

**Figure 2.2:** Hostel Typology B.

**Source**[190]

**2.1.7.1.3 Type C:** It is a student residence constructed with a short double-loading on horizontal access or corridor, a centrally placed service core, and distinct linear structures linked at ground level only, with one large sized social unit on each floor. This typology exhibits a large surface area to volume exposed to external climate, hence increases heat gain and loss in the interior and prone to noise pollution[190].

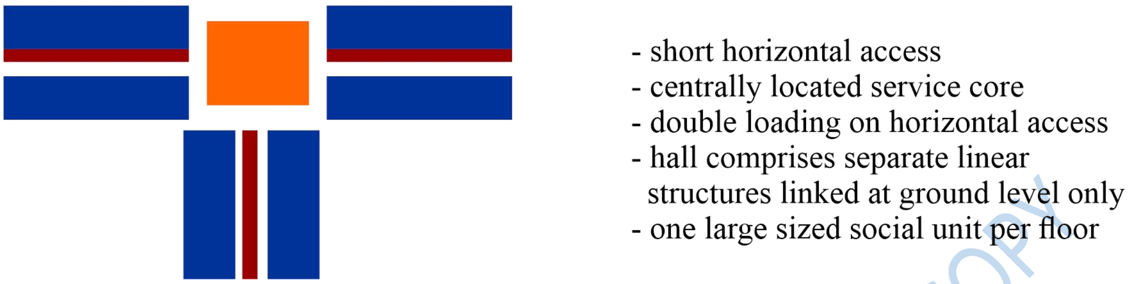



**Figure 2.3:** Hostel Typology C.

**Source**[190]

**2.1.7.1.4 Type D:** This structure has the morphological characteristics of a short single-loading horizontal corridor/access supplied by double end-located service cores, linked at ground level only with a series of fully enclosed courtyard constructions and two average-sized social apartments per floor. As this typology is a fully enclosed courtyard and single-banked building, it enhances a better natural ventilation and lighting, reduces temperature fluctuation and improves air circulation[190].

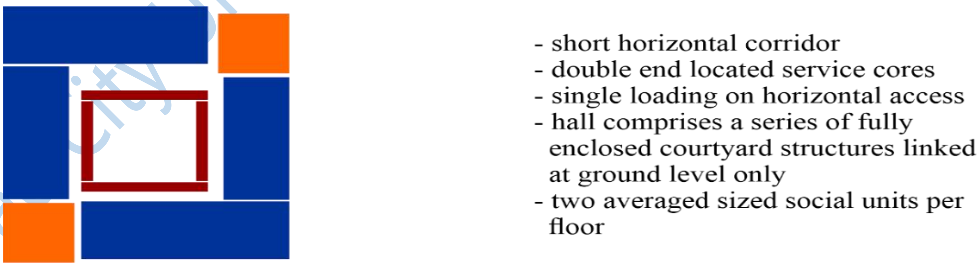



**Figure 2.4:** Hostel Typology D.

**Source**[190]

**2.1.7.1.5 Type E:** It is a student hostel design with a long partial double-loading on horizontal access/corridor, served by a single end-located service center and one average-sized social unit per level. The typology exhibits a reduced moisture accumulation, reduced heat loss and gain due to a partial double loading on horizontal access corridor of the typology[190].

- long horizontal access
- single end located service core
- partial double loading on horizontal access
- one averaged sized social unit per floor

**Figure 2.5:** Hostel Typology E.

**Source**[190]


**Figure 2. 6:** Legends of the Hostel Typologies.

**Source**[190]

### 2.2 Theoretical Framework

Theoretical frameworks are blueprints or guidelines for inquiry based on existing theory in a field of study and often represents research hypothesis. It consists of a combination of theoretical principles, structures, concepts and theories. Theoretical frameworks thus provides a theoretical basis for understanding, analyzing and designing methods for studying problems, making research findings more meaningful and generalizable. To better understand the indicators that determine the influence of Indoor Environmental Quality (IEQ) on students' wellbeing in hostel rooms for the purpose of indoor setting improvement, it is important to reinforce this investigation on self-explanatory and testable theories. Therefore, this study considers and identified Maslow's Hierarchy of Needs and Environmental Psychology theories.

### 2.2.1 Sustainable Development Goals (SDGs) Theory

The term sustainable development began to be widely used in 1987, when the World Commission on Environment and Development, also known as the Brundtland Commission, introduced this concept. This concept addresses the interaction between the environment and the promotion of development, ensuring current needs without compromising future generations[191]. However, concerns about this issue date back to the 18th century, coinciding with the advent of the First Industrial Revolution, when the increased use of machines to the detriment of human power demanded the use of fossil fuels for energy, resulting in more significant green-house gas emissions and global warming problems[192]. Today, construction is also a significant concern, as it contributes significantly to society in terms of infrastructure and consumer products. Therefore, projects in this field must incorporate sustainable practices to mitigate environmental impacts[193] and integrate social, economic and environmental issues into the development process[194]. In this way, assessing the energy performance of buildings is of fundamental importance when pursuing sustainable development[191]. For example, energy-inefficient buildings that lack waste-sorting and water-reuse systems can lead to higher operating costs[195]. In the same context, building cooling and ventilation strategies have undergone notable transformations. Before the 1950s, ventilation and air-conditioning systems were considered economically unviable, resulting in a greater prevalence of natural ventilation to maintain thermal comfort in buildings, mainly due to the availability of windows that provide access to fresh air and natural light[191]. However, with technological advances and the growth of urban areas, architecture has evolved, resulting in the more widespread adoption of mechanical cooling and ventilation systems. At the same time, operable windows have been replaced by fully glazed structures with no possibility of opening, rendering previous designs obsolete. Accordingly, the concept of bioclimatic architecture emerges, where the construction is planned in a way that is adapted to the local climate and employs passive approaches to enhance the quality of the indoor environment, aiming to minimize energy consumption to the maximum degree[196]. A bioclimatic project can optimize the natural environment by utilizing renewable energy systems and clean energy, reducing energy consumption for heating, cooling, and lighting and improving the quality of life in urban areas[197]. In this regard, governments in different nations are exploring methods to foster sustainability[198, 199]. For example, in the United States, investments have been directed toward renovating green or energy-efficient homes, addressing social inequalities and climate change, and promoting economic and infrastructural recovery[191]. It was revealed that the contemporary challenge lies in balancing energy supply and inhabitant comfort, requiring strategies that combine Indoor Environmental Quality (IEQ) with energy consumption[191].

In addition, there has been growing concern about sustainability in the built environment, focusing on mitigating environmental impacts and promoting social benefits[200, 201]. This concern has led to the popularization of the term "energy poverty", especially to describe the situation in which many families lack the material and social resources necessary to provide adequate energy and indoor comfort to their members. This negatively impacts their quality of life, as their heating needs are not met[191]. The influence of climate change on buildings reinforces the need for approaches that expand energy efficiency and sustainable development, incorporating renewable energy sources and conscious consumption[202]. However, the pursuits of energy efficiency and occupant comfort are not always aligned. Problems associated with energy consumption and IEQ in buildings have been pointed out by several studies covering various aspects that influence people's satisfaction with the built environment, such as air quality, thermal comfort, acoustics, lighting, furniture, maintenance, cleanliness, vibration, technology, aesthetics, appearance, privacy, and views, among others[203, 204]. These aspects will serve to investigate health and productivity, thus making it possible to pay greater attention to sustainability research along with the progress of the renewable energy sector, which presents numerous technological innovations in both industry and research laboratories[191, 205]. It is worth noting that adopting technologies does not always result in a decrease in energy consumption.

Therefore, projects should increasingly consider the behaviors, needs, and preferences of occupants to enhance the indoor environment of buildings[206]. From this perspective, adopting technologies involves using new methods, systems, devices, or practices aimed at improving performance, energy efficiency, sustainability, and other aspects related to the quality and effectiveness of buildings. In this context, the Sustainable Development Goals (SDGs), which were launched by the United Nations in 2015, play a key role in setting goals to be achieved by 2030[207, 208]. Consisting of 17 goals, 169 targets and 231 indicators, the SDGs broadly cover economic, social, and environmental issues[209, 210]. Responding to these ambitious goals, research exploring the relationship between Indoor Environmental Quality (IEQ) and sustainable development is on the rise, in line with the purposes of the SDGs[211, 212]. Therefore, the key Sustainable Development Goals (SDGs) realted to Indoor Environmental Quality and wellbeing are:

**SDG 3: Good Health and Wellbeing:** This goal focused to ensure healthy lives and enhance wellbeing for all at all ages. Thus, IEQ plays a significant role in maintaining occupants' hralth and wellbeing. IEQ components such as thermal comfort, Indoor Air Quality, lighting and acoustics therefore contribute to overall wellbeing of the occupants.

**SDG 4: Quality Education:** This is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Therefore, comfortable and healthy environments can promote cognitive function, productivity, concentration and learning performance of the students in the indoors.

**SDG 7: Affordable and Clean Energy:** This is stated to ensure access to affordable, reliable, sustainable and modern energy for all.Therefore, optimizing building design and operations lessen energy consumption in the course of maintaining good indoor environment.

**SDG 9: Industry, Innovation and Infrastructure:** This aims to build resilient infrastructure, promote inclusive & sustainable industrialization and foster innovation. In this regard, well-designed buildings with adequate, comfortable and satisfactory environment with thermal, IAQ, acoustic and lighting can enhance sustainable and resilient infrastructures.

**SDG 11: Sustainable Cities and Communities:** The focus of this SDGs is to make cities and human settlements inclusive, safe, resilient and sustainable. Hence, well and sustainable designed buildings with good IEQ will long way contribute to livable and resilient indoor environments

### 2.2.2 Maslow's Hierarchy of Needs Theory

Maslow's Hierarchy of Needs is a psychological theory that suggested human needs are arranged in a hierarchical order, from the most basic to the most complex. The theory posits that individuals must satisfy lower-level needs before they can address higher-level needs. According to the study, it was inferred that the students' wellbeing will be influenced after all the physiological and safety needs of the students are gratified. Maslow suggested also that quality of indoor environment is secondary to student needs and any attempt towards their performance requires wellbeing as an unavoidable pre-requisite physiological needs[213]. These psychological needs include the basic necessities of life required for human survival[214]. These needs may include sleep/rest, warmth, physical well-being, shelter. However, other needs cannot be pursued until these needs are met. Once physiological needs are met, students will then need the second level of Maslow's hierarchy. The second level is safety needs that include personal security, financial security, health and well-being, stable environment, and protection from accidents and illness[213].

Furthermore, love and belongingness as the third level refers to the desire for social connections, emotional relationships, and a sense of belonging with other people/room-mates in the hostel indoor and need to feel that they do fit in. The fourth level encompasses esteem needs, which include both self-esteem and the esteem of others. Individuals at this stage seek recognition, status, and respect from others, along with a sense of accomplishment and independence [213]. At the final level of the hierarchy, which can only be reached if all levels are previously met, students are now motivated through self-actualization needs. At this level, students have already met many of their personal goals and are now motivated to improve the people around them[214]. At the top of the hierarchy, the individuals strive to realize their full potential and achieve personal growth. This need is focused on personal development, creativity, and the fulfillment of one's capabilities[213].

Maslow suggested that as one moves up the hierarchy, the needs become more psychological and less physiological, with self-actualization being the ultimate goal of personal development. However, the study also acknowledged that not everyone follows this exact sequence and that different people may prioritize needs differently depending on their circumstances[213]. Therefore, in order to explain the influence of indoor environmental quality on students' wellbeing using Maslow's hierarchy of needs, this theory can be integrated into this research to understand how indoor environmental quality (IEQ) in students' hostels affects students' physical comfort and safety thus, influencing their wellbeing through addressing various levels of needs.

**Applications of Maslow's Hierarchy of Needs Theory**

Maslow's Hierarchy of Needs Theory provides valuable insights into understanding and addressing students' needs such as thermal comfort, indoor air quality, lighting and visual comforts which can greatly impact their productivity, motivation, satisfaction, comfort, engagement, and overall well-being in the hostel setting. The foundation of Maslow's hierarchy is based on fulfilling physiological needs, such as shelter, warmth, sleep, and physical well-being. In hostel setting, it is crucial to ensure that students' basic physiological needs are met by creating a conducive indoor environment for sleeping and study [215]. This implies providing essential quality and clean air for physical health, wellbeing and cognitive function. However, poor indoor air quality can lead to discomfort, dissatisfaction, lower motivation and health issues, which may hinder students' ability to focus and learn effectively[84]. Furthermore, adequate lighting and comfortable thermal conditions are crucial for maintaining physical comfort, wellbeing, satisfaction and concentration in the indoor, however, extreme temperatures and inadequate lighting can negatively affect students' wellbeing, satisfaction, study/reading habits and overall performance[216].

Safety needs encompass physical safety, emotional security, and a stable indoor environment. Students' hostel rooms must prioritize creating safe and secure atmosphere where students feel protected from harm and have trust in their surroundings. Implementing safety protocols, addressing a safe and secure environment is necessary for students to feel comfortable, satisfactory and focus on their studies. Issues such as poor indoor air quality (IAQ), safety hazards, and lack of emergency preparedness can create stress, anxiety and distract from study/reading activities[217]. Belongingness and love need refer to the desire for social connections, positive relationships, and a sense of belonging within a community. In hostel settings, fostering a supportive and inclusive indoor environment helps students feel valued, accepted, and connected. Encouraging collaboration, and teamwork, and cultivating positive peer relationships contribute to fulfilling these needs[218]. Therefore, adequate personal space and the ability to study without interruptions are important for maintaining social comfort, wellbeing and satisfaction and supporting academic success. Overcrowded and poorly designed hostels can lead to social stress and hinder students' wellbeing and productivity[219].

Esteem needs involve developing a sense of self-worth, self-esteem, and recognition. In academic setting, it is crucial to provide opportunities for students to gain recognition for their achievements, receive constructive feedback, and engage in activities that enhance their self-confidence. Encouraging student autonomy, acknowledging their accomplishments, and promoting a growth mind-set contribute to meeting students' esteem needs[220]. Therefore, a well-maintained and aesthetically pleasing indoor ambience can enhance students' self-esteem, wellbeing and motivation, however, poor IEQ may affect students' self-perception and their attitude towards studying and learning[221]. Subsequently, self-actualization needs further refer to the pursuit of personal growth, realizing one's potential, and achieving self-fulfillment. In the context of learning, supporting students' self-actualization involves providing opportunities for creativity, critical thinking, and personal development. This includes offering challenging tasks, promoting individual interests and talents, and encouraging students to set and pursue meaningful goals[222].

By considering Maslow's hierarchy of needs, an optimal indoor environment supports students' pursuit of personal wellbeing and academic goals. A conducive learning environment, including proper satisfaction and comfort, facilitates better study/reading and learning abilities and personal wellbeing & growth[223]. In summary, Maslow's hierarchy of needs concluded that the students' wellbeing is influenced after all the physiological and safety needs of the students are satisfied and therefore provides a useful framework for understanding how different aspects of indoor environmental quality impact students' satisfaction and wellbeing.

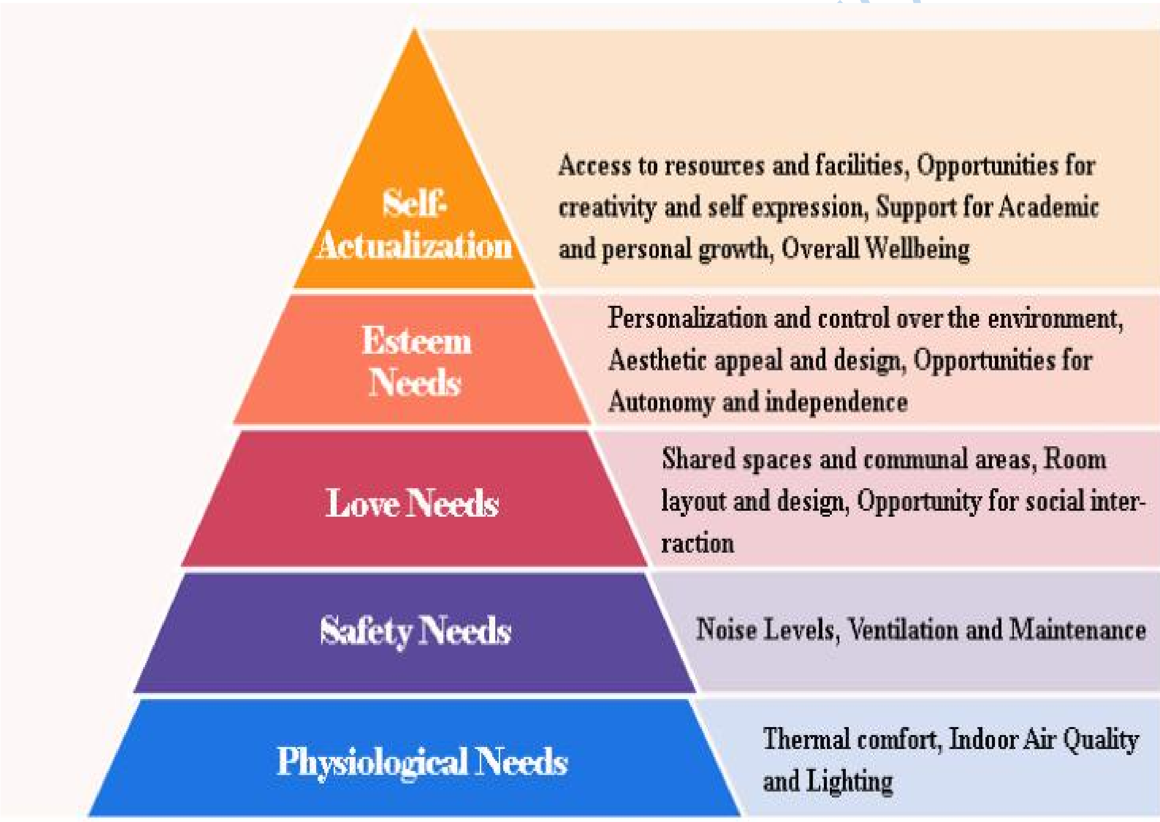



**Figure 2.7:** Maslow's Hierarchy of Needs Theory

**Source**[228]

### 2.2.3 Environmental Psychology Theory

Environmental Psychology Theory describes a shelter/home as the most important physical setting for most people[217]. It distinguishes the physical structure (house, apartment, hostel, etc) from its meaning home. Individuals normally called homeless might more properly be called houseless, if their residences lost its meaning (in terms of wellbeing, health, satisfaction, comforts etc), they truly are homeless. However, residential wellbeing depends on many determinants, including stage of life, socio-economic status, personality and values, hopes for the future, norms for one's peers, and relationships with neighbours. Of course, physical features of the residence such as its forms[224]; architectural styles[225]; floor plan, colours, indoor and outdoor areas of the residence, as well as cultural background affect residential preferences, choices, satisfaction and wellbeing. Poor quality housing affects the socio-emotional health of the occupants[226].

Furthermore, people arrange their residential interiors in fairly predictable patterns that are related to lifestyle, social class, and culture[227]. Adapting to new residences can be stressful, depending on whether a person has some choice in doing so, prefers to explore new settings in general or whether the change represents a downgrading[228]. Therefore, environmental psychology is the study of the interrelationship between individuals and their physical surroundings. This field investigates how environment influences users' satisfaction, thoughts, feelings, emotions, well-being and behaviours, as well as how individuals perceive and interact with their surroundings. The theory behind environmental psychology is that physical environments, both natural and built, can significantly affect human satisfaction, well-being, social behaviour, and cognitive functioning.

Diverse theories have been propounded to explain the relationship between humans and their environment. These include Stimulation Theory, Place Attachment Theory, and Behaviour Setting Theory. Howbeit, Stimulation Theories are theories including the arousal theory, focus on the impact of environmental stimuli on individuals which can be perceived as either arousing or non-arousing, and this arousal level can influence an individual's emotional and behavioral responses. Environments that are too stimulating may lead to stress, while those that are under-stimulating may result in boredom[229]. Furthermore, Place Attachment Theory emphasized on the emotional bonds that people developed within the specific places. Place attachment is the process through which individuals and groups form emotional and symbolic connections to particular spaces, influencing their identity and sense of belonging[230]. Lastly, Behaviour Setting Theory suggested that the environment can be understood as a series of behaviour settings, which are combinations of physical and social contexts that evoke specific behaviours. For instance, a classroom setting encourages learning and attentiveness, whereas a park setting may promote relaxation and play[231].

**Applications of Environmental Psychology Theory**

Environmental psychology examines the relationship between individuals and their surroundings, including how physical environments impact human behaviour, emotions, well-being and overall satisfaction. It is an essential aspect of theory in urban planning, architecture, and landscape design, as it helps Architects/allied professionals create spaces that promote satisfaction, well-being and positive social interactions. For example, understanding the principles of environmental psychology can lead to the design of more effective workspaces that enhance wellbeing, satisfaction and productivity or public spaces that foster community interaction. However, Indoor Environmental Quality (IEQ) is a crucial aspect of environmental psychology theory, particularly in contexts like student hostels, where the environment can significantly influence wellbeing, satisfaction and performance. Therefore, the influences of indoor environmental quality components as a crucial aspect of environmental psychology theory are as follow:

1. **Indoor Air Quality:** Indoor air quality (IAQ) is a critical component of IEQ and has a direct effect on students' cognitive function, well-being and satisfaction. Poor IAQ, characterized by high levels of carbon dioxide ($CO_2$), pollutants, and insufficient ventilation, can lead to fatigue, headaches, and reduced concentration, all of which impair wellbeing, satisfaction and performance[232]. Improved ventilation and air filtration systems have been shown to enhance comfort, wellbeing, satisfaction, cognitive function and memory retention, thereby supporting better performance[233].

2. **Lighting:** Adequate lighting, both natural and artificial, is another important factor in the indoor. Natural light exposure is linked to better mood, alertness, and sleep patterns, all of which contribute to satisfactory and healthy indoor[234]. Poor lighting, on the other hand, cause headaches, eye strain, fatigue, thus diminishes the reading ability of students[235,236]

3. **Noise Levels:** Noise is a well-documented environmental stressor that can interfere with satisfaction, wellbeing, learning and concentration. High noise levels, whether from within the building or external sources, can disrupt sleep and concentration, leading to decreased indoor wellbeing, satisfaction and performance[237, 238]. A study found that students living in quieter environments exhibited better wellbeing, satisfaction and performance than those in noisy conditions[239, 240].

4. **Thermal Comfort:** The temperature and humidity levels within indoors also play a vital role in indoor satisfaction and wellbeing. Thermal discomfort, whether due to excessive heat or cold, can lead to a decrease in wellbeing, satisfaction, cognitive performance and overall productivity[241, 242]. Maintaining an optimal thermal environment can therefore enhance students' wellbeing, satisfaction and ability to focus on their studies/reading.

In this regard, the indoor environmental quality of student hostels, encompassing air quality, lighting, noise levels and thermal comfort, plays a significant role in students' wellbeing, satisfaction and performance. Addressing these factors through thoughtful assessment of hostel roome IEQ can lead to improved learning outcomes, satisfaction, comfort and overall wellbeing of the students.

**Table 2.1:** Theoretical Framework and Research Objectives

| Research Objectives | Research Objectives | Applicable Theories |
|---|---|---|
| 1 | To determine the compass orientation of the hostel buildings and physical dimensions of the hostel rooms in the study area | Maslow's Hierarchy of Needs and SDGs 3, 4, 7, 9 & 11 |
| 2 | To examine the adequacies of IEQ components of thermal comfort, IAQ, lighting and acoustic of the selected hostel rooms in the study area | Environmental Psychology Theory and SDGs 3, 7, 9 & 11 |
| 3 | To examine the satisfaction of the students with the Indoor Environmental Quality conditions in the hostel rooms of the selected universities | Maslow's Hierarchy of Needs Theory and SDGs 3, 4 & 11 |
| 4 | To establish the impact of IEQ conditions on students' wellbeing in the hostel rooms of the selected universities | Environmental Psychology Theory and SDGs 3 &4 |

**Source:** Researcher's Summary from Literature Review, 2024

### 2.3 Review of Empirical Studies

#### 2.3.1 Thermal Comfort

This section evaluates studies on how users judge indoor thermal conditions in the built environment. Therefore, in a study to examine individual differences in thermal comfort and its contributing factors, a chamber and field research methodologies to determine sex, gender, and other variables were adopted. The study's finding revealed that, there is neither significant differences in weight or inter-group differences in preferred/neutral temperature between females and males, nor between the young and the elderly in thermal comfort. Moreover, females and the elderly are more critical of indoor thermal conditions and more sensitive to variations from an optimal environment than males and the young; however, once clothing and demographic characteristics are controlled, inter-group distinctions in thermal comfort are eliminated [243].

A research study was conducted in South Australia to evaluate the effects of individual characteristics on older people's perception and responsiveness to thermal conditions. The study employed an exploratory design to collect data from 71 respondents (aged 65 or older) in 57 households for over a period of 9 months in conjunction with a preliminary assessment of the effects of individual basic characteristics such as gender, body composition, frailty, and other factors on thermal comfort. In this study, it was discovered that physiological changes affect old aged people's thermal perception, sensitivity, and control; thus, old people can become vulnerable to excessive thermal conditions in their environment[244].

Additionally, a field study on students' perceptions of thermal comfort in Nepal school buildings in a temperate climate revealed that, while private school students selected a lower estimated comfort temperature, public school students felt comfortable and satisfactory at an average temperature of 27°C. This difference may have resulted from the private school students' use of more clothing insulation to withstand outdoor air temperatures beyond 30°C[245]. Both objective and subjective data collection techniques were used in the research work. The Griffiths technique is used to estimate the comfort temperature in the subjective method, which uses questionnaires with three voting opportunities for the subjects, at the start, intermediate and the end of each 45-minute session. A further field research study on responsive thermal comfort in Spanish primary schools over the summer season focused on recording environmental factors over 21 days and collecting questionnaires to analyze thermal comfort during the school year was carried out.

The field study took place at a school facility in Seville, Spain, with 67 pupils and three teachers spread over two free-running (FR) classrooms with fans and one mixed-mode classroom with a heating, ventilation, and air-conditioning (HVAC) system. The findings revealed that students in free-running indoor thermal environments were more comfortable and satisfactory than those in mixed-mode classrooms, with a growing difference in thermal comfort ranges compared to international standards. Students preferred to open windows and doors instead of utilizing fans or changing garments [246]. A study was conducted in Univwersity classrooms to investigate the students' assessments of indoor environmental quality components for a comfortable indoor work environment in Uli, Nigeria's warm, humid climate. By including the students in a variety of class activities, the study used a field subjective questionnaire/survey to collect responses from the students in two university classes. It was determined that thermal comfort was ranked as the IEQ component that gives them the greatest concern for comfortable and satisfactory indoor classrooms. Students also prefer to move their seats close to or beside windows in order to be more comfortable during the dissatisfied times[247].

A study was further carried out to explore the indoor thermal climate in residential buildings in Tibet, China, using monitored on-site measurements of outdoor environmental variables and a survey questionnaire for inferential analysis. The results showed that the allowable temperature range is significantly lower than the comfort range value. Fires/stoves routinely utilized for heating during severe cold weather conditions may result in poor indoor air quality, affecting people's health and well-being[248]. In an effort to determine the association between low ventilation flow and student thermal comfort adaptivity in a naturally ventilated residential college in Malaysia's tropical climates, the authors used both quantitative (questionnaire) and qualitative approaches to collect information from the residents and college management authorities. The outcome revealed that, in the residential college, inadequate ventilation rate is positively significant or connected to poor interior thermal comfort[249]. As a result of the degree of heat stress in the hostel, adaptive behaviours include using the mechanical ventilation system and dressing in thinner, more comfortable fabrics.

Similar to this, a research was carried out in a naturally ventilated manufacturing building in India during the country's hot summer and cold winter months to inquire into the workers' subjective perceptions of their working environment and any changes in their behaviour. Using ASHRAE Standard 55 Class-II, a subjective field survey of the "Right Here, Right Now" and "Transverse Type" questionnaires was conducted. Simultaneous measurements of the most prevalent indoor environmental factors for the winter and summer seasons were also made. The study's findings showed that employees felt comfortable in the industrial facility throughout a wider comparatively higher and lower ranges of indoor temperature. The finding further showed that, workers need higher air flow rates as climatic conditions change from winter to summer, and undesirable thermal conditions have been proven for decreased productivity[250].

Further field study was conducted to assess the thermal sensations of occupants in naturally ventilated (NV) and air-conditioned (AC) classrooms at two technical institutions. 383 survey questionnaires from NV classrooms and 285 questionnaires from AC classrooms, as well as on-site measurements of both indoor and outdoor weather conditions were adopted as methodology. The result revealed that, students felt more refreshed and comfortable in naturally ventilated learning environments than in air-conditioned classrooms. A rise in $CO_2$ levels after a few hours in air-conditioned classrooms may cause learners to slow down and have difficulties in concentration throughout long lecture hours[251]. The survey also found that students preferred more air flow and openness with more interaction with nature over confined air-conditioned spaces.

Also, in the assessment of student comfort level in Pakistan universities structures, the aims were to quantify the students' satisfaction level and to analyze the components that influenced the students' comfort the most. The authors used a quantitative method, specifically a questionnaire. Two departments were chosen at random with a ten-point interval, and a sample of twenty-seven students was selected using a systematic sampling technique. The study found that students face substantial indoor environmental comfort difficulties, particularly thermal comfort, necessitating significant attempts to enhance academic learning productivity [252].

The evaluation of thermal comfort with respect to building designs in naturally ventilated open-plan and enclosed-plan studio classrooms was carried out in two typical university buildings in warm-humid, Nigeria. The study used a questionnaire with a seven-point ASHRAE thermal sensation rating scale to collect subjective data from students about the thermal conditions. The findings revealed that, more respondents felt satisfied and at comfortable degrees with the indoor thermal environment in the open classroom than in the enclosed classroom but none of the classrooms investigated met the ASHRAE Standard 55's 80% criterion for a comfortable indoor environment[253]. It also demonstrated that indoor temperatures are influenced by building designs[253].

In a similar research, assessment of assessments of indoor environment quality in two contemporary intelligent buildings in Poland was investigated. The adoption of objective survey measurements of carbon dioxide concentration, air and globe temperatures, and relative humidity were taken up by the study and applied to 117 rooms at intervals of 1.5 years. Additionally, the study also used subjective evaluation by analyzing participants' acceptance, preference votes, and thermal sensation using 1369 questionnaires. The study showed that, the users' assessments of indoor environment quality and thermal comfort were extremely poor because of these factors' interdependency and dependency on the operating temperature of HVAC (heating, ventilation, and air conditioning) systems. It was found also that thermal comfort ascertained to be the utmost vital component for guaranteeing residents' wellbeing[254].

In the analysis and evaluation of IEQ in two public architectural campus buildings in Karachi, Pakistan's lecture halls. A subjective approach utilizing a questionnaire survey and physical metric measurements were used. The findings indicated that the subjects are not comfortable with the humid and hot indoor conditions that have emerged due to a combination of the building's insufficient ventilation and the nearby outdoor climate. The results also suggested that, a more comfortable environment can be created through cross-ventilation enhanced from modified opening position, improved exterior shading devices, and supply of more vegetation [255]. In the investigation of indoor ventilation conducted in Multi-habited houses, Ogbomoso Nigeria, the study's data was gathered through the use of a questionnaire in likert scales. Therefore, the study selected one (household-head) out of every five residential buildings using a systematic sampling technique, thus yielding a sample size of four hundred and nine (409) from a sampling frame of eight thousand one hundred and seventy three (8173) residential structures in the core of Ogbomoso. The findings of the research showed that, the inhabitants were not comfortable at different times of the day due to insufficient indoor ventilation rate. The study suggested that, natural ventilation alone cannot provide appropriate thermal comfort in the warm humid climate indoors, particularly in the afternoon and evening[256].

A study of adaptive thermal comfort during the summer in medical apartments was conducted in French city of Troyes. The research adopted both subjective and objective physical measurements of relative humidity, mean radiant temperature, air temperature, and air velocity. The objective measurement was conducted in six buildings or group of building while subjective survey was carried out among the patients and healthcare staff in the shared spaces within each building, resulting to a total of 423 questionnaires. The study discovered that patients were generally unsatisfied with the thermal environment of their homes, with an adaptation temperature of 250C [257]. Another study was conducted to investigate the thermal comfort of naturally ventilated university hostel buildings during the hot season in a warm humid region. A subjective assessment employing a total of 100 questionnaires and physical measurements of the prevailing indoor environmental factors of air temperature, air velocity, and relative humidity using the Kestrel 4500 Pocket Weather Tracker were adopted. It was found from the study that, all thermal comfort metrics fell below the 80% comfort range defined by ASHRAE standard 55 and ISO 7730 standard. This suggests that hostel inhabitants were dissatisfied with their local thermal environment, and suggested that natural ventilation alone cannot provide acceptable thermal comfort levels for its occupants in a warm humid region [258].

Furthermore, an examination of indoor comfort and adaptation in low-and middle-income dwelling homes during a dry season was carried out in Nigerian city. The study examined the performance of 171 households in four distinct locales. Post-occupancy surveys were performed to assess how the buildings and inhabitants adapted to the thermal environment. Subjective thermal comfort surveys were conducted in eight low-income residential homes, and physical measurements were taken using the building simulation method due to the short measurement time. It was found that occupants felt dissatisfied and displeased with their thermal environment, and the frequent occurrence of this thermal discomfort highlights the need to investigate the possibilities of lowering indoor temperatures, particularly through passive means[259].

In another study to investigate into how university students perceived thermal conditions in a naturally ventilated workshop facility during the several seasons in India's composite climate, a total of 1460 subjective responses was gathered during the field study in 2019. Standard Effective Temperature was utilized as a logically derived thermal comfort index to study the combined effects of air temperature, relative humidity, and airspeed on perceived thermal sensation and occupant preference under high metabolic rates. The study's conclusion was that, the residents were uncomfortable and dissatisfied indoors, and they desired increased air movement together with an increase in the standard effective temperature [260].

In a tropical studio-style university classroom to determine thermal comfort based design consideration was subjected to thermal comfort testing utilizing the Predicted Mean Vote (PMV) and Standard Effective Temperature (SET) models. It was revealed that, the PMV and SET values for indoors as well as outdoors of the classroom are significantly greater than the recommended comfort zone, and a desirable thermal comfort state is obtained by air conditioning and increasing air velocity within the classroom[261]. Also, assessment of thermal comfort model for implication in tropical climate was examined. The study used meteorological data, such as air temperature, relative humidity, globe temperature, and air velocity, to calculate the Standard Effective Temperature (SET) and Predicted Mean Vote (PMV), along with clothing insulation and metabolic rate. This was continually recorded during field measurement with a one-minute time interval for a seven-hour period between 9:00 and 16:00 on typical summer days from June 11 to June 13, 2019. The study found that, the occupants felt comfortable when the indoor temperature was between 24°C and 26°C [262].

Also, thermal comfort assessment in selected lecture theatres was conducted in Gidan-Kwano campus. Physical measurements of floor plans and cross-sections, as well as climatic indicator measurement of indoor air temperature and relative humidity were collected. The study's findings revealed that the lecture theatres' indoor thermal comfort falls short of thermal performance standards due to excessive temperature and relative humidity, low wind velocity, poor orientation, and so on[263]. Furthermore, in a study conducted into occupants' responses to thermal comfort conditions in traditional core areas of Ibadan and Ogbomoso cities, the two cities' climatic data were subjected to the Evans scale in order to estimate the daytime and nighttime thermal stresses experienced by residents. Additionally, subjective questionnaires were used to gather data on how residents responded to changing thermal conditions. Lastly, the data were analyzed using descriptive and inferential statistics. The findings revealed that, in both cities, morning hours are the most comfortable, afternoon hours provide the most hot discomfort conditions, and evening hours are mostly associated with cold discomfort [264].

In the evaluation of the natural ventilation provision for comfort in a few chosen residential estate buildings was carried out. Data was gathered from 91 out of the 273 buildings which were randomly chosen for a field survey using 7-point ASHRAE scale questionnaires. A simulation technique to infer the internal environmental conditions, meteorological station data for bioclimatic analysis, and architectural building drawings to determine the spatial analysis of the various typologies were also utilized for the study. It was found that, revealed that nearly all of the buildings' indoor spaces have sufficient natural ventilation, with indoor wind speeds between 0.21 and 0.24 m/s being preferable to air-conditioned interior spaces[265]. Furthermore, a longitudinal survey was conducted in six randomly selected residences during the winter and spring seasons of Qatar to examine the occupants' thermal comfort and sleep quality. A total of 833 subjective thermal and sleep quality responses were collected before going to bed and after getting up. It was shown that the residents preferred warmer sensations and felt colder for most of the day. Nonetheless, the residents slept well, and their self-reported total self-rated sleep quality improved considerably with thermal acceptability[266].

In order to examine the hot-humid indoor climates of the assessed buildings in terms of air temperature, globe temperature, relative humidity, and wind velocity, the study conducted a field survey at the IBS building in a Northern Malaysian city. Therefore, the clothing insulation group and metabolic rate of the occupants were used with multiple and stepwise regressions to identify the independent variable for neutral temperature prediction. The analysis of the assessment of thermal comfort factors in Industrialized Building System (IBS) residences found that, air temperature, air humidity, wind speed, as well as other factors, all have a significant impact on the dwelling's condition, uncomfortable living conditions and make it difficult for residents to perform daily tasks effectively and efficiently[267].

A comparison of adaptation measures and thermal comfort for conventional and contemporary multi-story naturally ventilated dormitory buildings during India's monsoon season was carried out. In order to gather data for the study, 945 questionnaires were distributed to 470 residents of 419 rooms to administer. The questionnaires included objective measurements of the hostel buildings' architectural characteristics as well as values for thermal ambient components. It was determined that the mean room temperature in conventional and contemporary hostel buildings did not significantly differ from one another. It was discovered that turning on the fans and then opening external doors and windows were the main adaptive measures taken by the students to restore the comfort[260]. An objective measurement of internal environmental parameters using a microclimate meter was adopted to assess the indoor thermal conditions of the intelligent lecture room building at Kielce University of Technology. The field questionnaire was administered to a total of 164 people aged 16-24, comprising 97 men and 67 women. The study's findings revealed that, the students found the building's temperature range to be both acceptable and comfortable, matching all of their expectations. Further evidence revealed that learners enjoy and feel better in colder conditions[268].

### 2.3.2 Indoor Air Quality

This part analyzes previous researches on how users evaluate indoor air quality in the built environment. In a field experiment in Asia, the effects of two distinct ventilation rates and two filter settings on call centre operators' performance in their day-to-day work were examined. There were four conditions, each lasting two weeks, with the ventilation rates being 2.5 l/s-person and 25 l/s-person and the filters being either new or six months old. Every week, surveys were used to gather data on the prevalence of acute health complaints, the subjective assessment of the indoor ambience, and the perceived air quality. Call time was used as a basis for evaluating work productivity. The findings demonstrated that higher productivity was only positively correlated with a high ventilation rate when the filter was brand-new; a negative correlation was noted if an old filter was in use at the period of the increase in ventilation.

The subjective assessments' outcomes also demonstrated a relationship between new filters and people's perceptions of the air as being noticeably healthier and more acceptable. The participants reported having less dry skin and thought the workspace was cleaner and brighter[269]. With a new filter installed, increasing the ventilation rate was linked to a considerable reduction in nose and eye irritation, an improvement in the environment's perceived brightness and cleanliness, and an overall improvement in wellbeing. An almost significant correlation was found between higher ventilation rate and better performance. The hypothesis that there is a correlation between acute health symptoms and subjective evaluations of the indoor environment and productivity as measured quantitatively is supported by these results.

A study to examine the effects of varying the temperature from 22.5 to 24.5°C and the ventilation rate from 5 to 10 l/s per person on call time was conducted. For a total of nine weeks, the four conditions were subjected to the test by examining operator responses to a questionnaire regarding the indoor ambience, acute health symptoms, and perceived productivity, as well as talk and hold times. The subjective outcomes varied greatly between the conditions in a variety of ways. Increased perceived warmth, headache, difficulty in concentration, cold hands and feet, and a 9% decrease in reported productivity were all significantly connected with higher temperatures[270]. The report does not specify which questions were used to assess perceived productivity. Reduced perception of air stuffiness was strongly associated with higher ventilation rates. The temperature and ventilation did, however, have substantial interaction effects, with a decline in ventilation rate at the lower temperature leading to an almost significant rise in headache. Three months preceding the experiment, the ventilation systems' filters were exchanged. Decreased air quality and a higher felt stuffiness of the air were linked to higher temperatures and higher humidity levels. Four distinct clusters were formed from the symptoms in order to further investigate the subjective responses. Talk time was greatly associated with the first cluster of neurobehavioral symptoms (headache, trouble concentrating), and the fourth cluster of symptoms related to dryness and nose. The findings demonstrate a good degree of agreement between acute health symptoms and subjective assessments of the indoor environment and productivity.

A study was done to investigate how temperature interventions in an office building influenced the users' productivity. The Remote Performance Measurement Tool (RPM-tool), developed to make productivity measures in actual office buildings simpler, served as the foundation for the study. The internet-based tool comprises two questionnaires and multiple performance tests to assess the subjective perceptions of the indoor environment as well as productivity, which is quantified statistically. Three simulated office work tasks; text typing, proof-reading, and mathematical calculations, all constituted the performance examinations scored according to accuracy and speed. Although the authors note that similar performance measures could be employed in real offices, and they have previously been tested in experiments in the laboratories. It is preferable to conduct the tests in the afternoon after the subjects have spent many hours indoors, as this is thought to make them less alert and more sensitive to the conditions of the environment. The questionnaire inquired questions about perceived productivity, acute health complaints, and thermal feeling. It takes twenty to thirty minutes to complete the RPM test. The instrument was utilized in a series of office buildings that housed a Danish bank.

By modifying the temperature set-points in two buildings, two distinct temperature conditions were produced. For the duration of the two-day intervention testing, the study's 200 participants were told not to open the windows. While efforts were made to maintain constant environmental conditions, the temperature conditions that were attained were about 21 °C in the cool and 25 °C in the warm conditions. The addition task showed a significant 10% increase in performance in the cooler condition, but no other significant relationships between temperature and other performance tests were detected. There were significant correlations found between the respondents' thermal perception and temperature, but not between temperature and acute health conditions or perceived productivity. These results demonstrated that office workers' productivity may be influenced by indoor temperature in specific instances and that thermal perception is consistent with ambient conditions[271]. Nevertheless, despite the better results in the addition test, perceived productivity remained same throughout the conditions and greater productivity was found correlated with a lower air temperature.

Investigation into how primary school pupils' cognitive performance was affected by ventilation rates and $CO_2$ concentrations was conducted. Two distinct air quality conditions developed in a classroom comprising children aged 10 and 11 by either having the windows opened or closed. After spending a few hours in the classroom under one of the conditions, the 18 kids who took part in the study had a 10-minute test to assess their cognitive ability. The conditions led to $CO_2$ concentrations of about 690 and 2909 parts per million, respectively. The speed and accuracy of responses to multiple tasks and one memory task were used to evaluate the cognitive test findings. The subjects' subjective assessments of their individual feelings of calmness, alertness, and mood were also carried out. The overall speed, which is considered to be a strong evidence of concentrated attention, significantly improved in the results. While there were no appreciable effects on accuracy, there was an obvious increase in calmness. This study demonstrates that improving the ventilation rate can be achieved even with simple methods, leading to noteworthy improvements in cognitive tests, which are used as a focus indicator. It is believed that the ability of pupils for concentration affects their long-term learning and, consequently, the outcome of their academic endeavors. There is a relationship between subjective feelings and productivity, as evidenced by the increased ventilation's correlation with both enhanced mood and greater quantitatively assessed productivity [272].

The temperature between 20 and 25 °C and the outdoor air supply between 3 and 10 l/s person were altered in a study on children's performance and classroom conditions. Through the use of numerical and verbal tests that evaluated accuracy and speed, the productivity was quantitatively assessed. The findings demonstrate that raising the ventilation rate by two-fold was related with an 8% rise in test scores, as well as a significant improvement in subjective impression of the air according to both children and an adult sensory panel[273]. Reducing the temperature from 25°C to 20°C resulted in significant improvements in four out of eight performance tests, as well as the sense of fresher and less warmer air. Furthermore, the ventilation rate in 16 school classrooms in the UK was examined by installing movable mechanical ventilation systems in the majority of naturally ventilated classrooms. A total of 330 students took part in the research. It examined whether elevated ventilation rate, cognitive function, subjective perception of the surroundings, and the intensity of acute health symptoms were correlated. Four of the nine performance tests showed significant improvements in either accuracy or reaction time; these improvements ranged from 2.2 to 15%. Only a few significant gains in subjective assessment were observed[274]. The study also revealed that most schools had relatively high $CO_2$ concentrations preceding the intervention, and that routine window openings had a major role in ventilation. According to the study's findings, the subjects' ability to work is greatly affected by the quality of air in the environment.

Additionally, pupils between the ages of 10 and 12 were exposed to varying ventilation rates in four classrooms spread across two school buildings. The classroom's ventilation gadgets were able to provide the various ventilation rates. Every other condition kept the same. The reading and comprehension, grammatical reasoning, addition, and number comparison were the performance tests. Every Friday, questionnaires with questions regarding acute health problems, perceptions of the indoor environment, motivation, and fatigue were used to conduct subjective evaluations. There were $CO_2$ concentrations of about 900 and 1500 parts per million, respectively, due to the high and low ventilation levels. The tests were graded according to the total number of precise responses and errors[275]. The authors selected to subjectively delete a few extremely poor performance results because it was apparent that some of the subjects weren't attempting to complete the tests on time. By evaluating the entire sample, all four tests showed significant rises ranging from 3.2 to 7.4%. The findings suggested that the ventilation rate had a major effect on children's short-term productivity. The relationship between the indoor environment and productivity was quantitatively determined by granting staff in a new building more control over the environmental conditions of their workplace. The study discovered that quantitatively assessed productivity rose by 16% when compared to a conventional building without personal control[276]. It was discovered, meanwhile, that the increased control alone only resulted in a 3% rise. The number of forms that the employees at an insurance company filled in each week was used to measure their level of productivity. Better thermal comfort for women was linked to the increased controllability. Thus, greater control has been linked with greater thermal satisfaction as well as increased productivity. The results also implied that a high degree of personal environmental control may lead to higher levels of productivity.

The relationship between unsatisfactory indoor environmental conditions and perceived productivity, environmental satisfaction, and test-simulation performance was carried out. Over the course of eight months, 2261 survey responses and test participants completed the survey; the subjects had spent a minimum of at least six to seven hours in the offices at the time of the survey and test. The research questioned about perceived productivity, motivation, mood, fatigue/alertness, distractions, feelings, and environmental discomfort in addition to questions about lighting, noise, and thermal climate satisfaction. On a scale of "much less productive than average" to "much more productive than average;" productivity was measured. The "stroop test" was used to assess cognitive ability. It required participants to report a word's colour rather than the colour the word describes, and it was scored mostly on accuracy and speed. The number of environmental factors that participants regarded as having the lowest possible level of satisfaction was used to calculate a factor known as "environmental stress," which was used to determine the dissatisfaction rate of the environmental conditions. It was discovered that there was an important link between stress level and perceived productivity i.e. the higher the stress, the lower the productivity, as well as between stress level and the frequency of headaches, changes in mood, and "feeling off." The feeling of dissatisfaction with the environment was linked to the mood (between unhappy and joyful). The outcomes of the cognitive performance tests correlated significantly with the subjective assessments of motivation, mood, and distraction. The findings of the cognitive performance assessments were also connected to mood and "feeling off" [277].

### 2.3.3 Acoustic/Noise

This part analyzes relevant studies on how to evaluate acoustic/noise in the built ambiences. In analyzing the impacts of classroom reverberation on reading abilities, discomfort from indoor noise, and school attitudes in second graders with the goals to find out how classroom acoustics affect learning performance and wellbeing in primary school students. In order to gather information on the acoustic conditions of the classrooms and the performance of 398 children from 17 classes with mean reverberation times ranging from 0.49 to 1.1 seconds, a performance and subjective questionnaire was used. According to the findings, kids from classrooms with poor acoustics did worse in a phonological processing task than children from schools with better acoustics. A higher volume of indoor noise was indicated as a cause of impairment in the classrooms[278].

In an effort to compare acoustic comfort of classrooms in traditional and contemporary school buildings to Kerala's tropical warm-humid climate, the performance of a vernacular school classroom to a modern classroom, preliminary and in-depth surveys were carried out. Therefore, in order to measure two key acoustic parameters of background noise and reverberation time that affect the acoustical comfort in the classrooms, the surveys were carried out in the classrooms of ten vernacular and ten modern schools across each survey period. Teachers and students were given questionnaires to complete in order to assess the users' degree of satisfaction, and the results of the scientific analysis were compared with the users' responses. The findings showed that both teachers and students preferred the acoustics of contemporary classrooms over those of traditional classrooms, as they improved learning performance[279]. Thus, enhancing the acoustical comfort in classrooms is essential for increasing student performance.

A research in Poland was conducted on the effects of acoustic treatment in school rooms on the well-being and performance of tutors and students. The equivalent sound level, reverberation time, and speech transmission index were measured objectively in this study both before and after acoustic treatment. 378 pupils and 44 teachers received the questionnaire survey designed to measure the acoustic change feelings Scale for teachers and students. The results showed that both pupils' and teachers' performance and wellbeing were significantly improved. As a result, enhancements in the users' degree of concentration, short-term memory, and work pace were noted. Teachers and pupils reported a noticeable decline in fatigue and aggression as well[113].

The acoustical and general environmental quality of secondary school classrooms was assessed both subjectively and objectively. The research employed a methodology of a subjective survey to gather data on 51 secondary school classrooms, some of which had undergone acoustical renovations, on their perceived environmental quality. Eight of the 51 classrooms were used for the objective acoustical measurements, which served as a representative sample of the various classroom types that were the subject of the study. 1006 students were given a questionnaire with questions about both overall quality and its individual components, such as indoor air quality, thermal, acoustical and visual quality. According to the study, non-renovated classrooms had lower acoustical satisfaction than renovated classrooms, which led to a decline in concentration. The result revealed that, the average noise disturbance, scores, and learning are more strongly correlated[280].

The effect of noise on elementary school pupils' performance on a range of literacy and speed tasks in the classroom was investigated. It was noted that on speed of processing tests, children in the babble and environmental noise conditions scored significantly worse than the kids in the base and babble conditions. But only in the babble condition did performance on the verbal tasks significantly worse[281]. Six year 3 classes totaling 158 children participated in the research study. Classes were randomly assigned to one of three noise environments: classroom babble, babble plus environmental noise, or babble and environmental conditions. Later, the children's performance in these conditions was contrasted with that in the base, or typical noisy conditions, by the children. An assessment of public school classroom acoustics showed that, for all three constructive designs examined, the acoustical quality of the assessed classrooms was poor and was inconsistent with standard[113]. Three constructive designs, two of which were built under each of the three designs, totaling six schools, were examined in the study and are situated in the Curitiba, Brazil metropolitan context. Then, the reverberation time and sound insulation results were contrasted to Brazilian Standard reference values.

Similarly, an assessment of the impact of various enclosed and open-plan classroom acoustic conditions on speech perception of kindergarten-aged Australian children was conducted. The impact of acoustics on speech perception was tested in four Kindergarten classrooms: a semi-open plan learning environment (205 children), a fully open plan triple classroom (91 children), an enclosed classroom (25 children), and a double classroom (44 children). While neighboring classes engaged in quiet versus noisy activities, 22 to 23 children, aged 5 to 6, in each classroom participated in an online four-picture choice speech perception test. According to the study, as fully open-plan classrooms generate a lot of unpleasant noise levels that impairs speech perception, they are not appropriate environment for critical listening exercises with young children[282].

The effects of environmental and classroom noise on the academic attainments of primary school children in England and Wales were studied through an approach that assessed children's academic performance employing a standardized national assessments of literacy, mathematics and science. The study sought to determine how children between the ages of 7 and 11 performed on tests after being exposed to outdoor and classroom noise on a regular basis. The results demonstrated that noise from outside significantly reduced performance, with the effect being lower for the younger children than the older. It is also indicated that noise from individual external events has a greater impact on children's test performance than internal classroom noise and background noise levels[283]. An evaluation to examine the influence of noise in educational environments on children's academic achievement in primary school was conducted in Ahvaz. In the process, a random selection of 210 male primary school pupils was used for the study's sample, and they were given questionnaires. The achievement motivation questionnaire developed by Hermance, and the researcher-constructed questionnaire (observation checklist to examine the physical variables of noise) together with student interviews were used as data gathering instruments. Descriptive and inferential statistics were utilized in SPSS-21 to evaluate the information gathered. The findings of the study revealed that, noise has a negative influence learning attitude of the kids [284].

### 2.3.4 Visual/Lighting

According to a study on the relationship between academic performance and visual health in school-aged Children in Spain, Children who performed poorly in the classroom had worse visual health than those who performed well academically[285]. 11406 elementary school students falling within the ages of 6 and12 years undertook a visual screening as part of the study's methodology. In order to identify any visual issues, a basic optometric screening was conducted together with the collecting of demographic data and questionnaires relating to children's and families' visual habits. Additionally, it was discovered in a thorough literature analysis on the effects of lighting on children's learning environments that pupils' task-switching performance of accuracy, speed, and expression increases more when they are exposed to higher correlated color temperature (CCT) light. Qualitative, quantitative, mixed-method and quasi-mixed-method methodologies were all used. Additionally, variables like the test score progression in standardized assessments, user's behaviour, mood, and concentration over time were examined as test parameters[286].

Two fourth-grade classrooms with 27 pupils each were used as the control and experimental groups in a field experiment. The students in each classroom were ten years old on average, and natural light was illuminating from one side of the classroom. Since the experimental group switched to solid-state lighting (light emitting diodes, or LEDs) with three lighting conditions during the second week of the study, as described in the laboratory study. The two groups worked on arithmetic problems under various lighting exposures. However, during the trial, the control group made use of the fluorescent lights that were already in place. According to the findings of the study, Correlated Colour Temperature (CCT) illumination has significant effects on both academic and recreational activities[287]. Therefore, 738 pupils were chosen by a systematic method of sampling for a cross-sectional study that investigated into how lighting affected students' performance in Delhi school classrooms. The lux metre "Testo-545" was used to record illuminance data, which was used to illustrate the lighting levels in the classroom. The speed and accuracy of the d2 test, developed by Brickencamp and Zilmer, was also used to evaluate the performance of the students. Data collection using a questionnaire and interview format was conducted to find out how students perceived regarding the illumination in the classroom. The findings indicated that the illumination in the classroom significantly affected student's ability to concentrate and perform. It was also mentioned that a classroom with illumination levels between 250 and 500 lux is strongly linked to pupils being more concentrated, which enhances performance and scores[288]. Therefore, it is decided to increase natural light by windows and doors that are positioned strategically or artificial light using appropriate lamps and luminaires within the classrooms.

In order to examine the effects of illumination on academic performance and learning in Ahvaz's elementary school population, a cross-sectional study comprising 210 randomly selected pupils was performed. Questionnaires were distributed to students at random and cluster sampling was carried through proper allocation. The researcher-constructed questionnaire (an observation checklist to assess the physical parameters of learning environment lighting) and Hermance's achievements motivation questionnaire were used as data collection methods, along with student interviews. SPSS software was applied to analyze the study's data. According to the study, elementary school pupils' learning and academic performance are significantly impacted by lighting[289]. Therefore, while designing and furnishing educational spaces, natural light (windows, valves, etc.) or artificial light (lamps or different types of lights) must be used to offer lightning in the classroom.

Similarly, over the course of a school year, the effects of daylighting and other aspects of the indoor classroom environment on students' performance and learning were investigated in a few faculties at the King Abdul-Aziz University campus in Jeddah, Saudi Arabia. Correlation analysis was used in the study to compare 400 students' performance across 20 classrooms at the selected faculties. The classrooms were spread across several floors of buildings used for education. Statistical modeling was utilized to examine the relationship between daylight in classrooms and the academic performance of learners, even with the presence of traditional descriptive learning variables. To assess whether there would be an impact of other variables on students' performance, other factors such artificial light, acoustics, thermal comfort, and indoor air quality were further investigated[290].

Thus, a study was undertaken to interview academic staff in order to investigate the impact of classroom daylighting on the academic performance of learners. As a result, it is evident that daylighting in classrooms has a significant impact on the learning environment as daylighting decreases running costs, enhances students' vision and perception, enhances occupants' comfort, health, and productivity[291]. Thus, the amount of natural light that enters classrooms should therefore be maximized, and the lighting of areas that fall within students' visual fields should be managed. Also, a longitudinal field survey assessing the visual comfort of daylight and sunlight areas in classrooms was investigated in Kashan, Iran. Throughout the course of a school year, the study used procedures that involved both subjective and field measurements, which were conducted simultaneously in two differently oriented classrooms (south and north).

A subjective study measuring students' perceptions of visual comfort in daylight and non-daylight classroom environments was carried out using questionnaires. Additionally, dynamic daylight metrics such as Annual Sunlight Exposure and spatial Daylight Autonomy were included. These were formalized in LEED V4 and subsequently compared to student assessments. The findings indicated that the majority of students do not experience much direct sunlight or glare in classrooms in both sunlight and non-sunlight areas of the classrooms[292].

In a study aimed at improving student achievement in California, Washington, and Colorado classrooms, a study sample of more than 2000 classrooms were adopted. Under the task performance of reading and arithmetic test scores, students were exposed in their classrooms to a larger amount of daylight. Research revealed that learners who received more natural light in their classrooms performed better on mathematics and reading tests, with 2 to 26% higher test scores than those of students who experienced less natural light[293]. Additional empirical investigation was carried out to examine how architectural spatial characteristics affect student performance. The study focused at how 583 elementary school pupils in Galicia, Spain, related to their learning environment in terms of mathematics and creative activities. Additionally, the Indoor Physical Environment Perception scale was developed, verified, and used in 27 classrooms. The findings confirmed that students do better academically in brighter classrooms[294]. Thus, young children may distinguish between different lighting needs based on the work at hand.

In attempt to assess the thermal, acoustic and lighting comfort conditions in seven classrooms at the University of Pavia in Italy, both subjective and objective measurements were conducted. In order to understand more regarding the students' perceptions of lighting and acoustic comforts, measurements of the primary indicators of thermal, acoustical, and visual comfort were conducted, and new targeted questionnaires were designed specifically. The outcome demonstration showed a strong association between the perceived visual comfort and the average measured illuminance value[295, 296]. Likewise, a field study to investigate how indoor lighting affects students' visual perception and cognitive performance in the University classrooms in China was conducted. In two experiments, light-emitting diode (LED) sources and LED panel sources were installed in typical classrooms as part of the study's conceptual approach. 79 college students were asked to complete a series of visual tests under the two lighting conditions. These tests were carried out twice, one before and another after a two-hour self-study in each type of lighting. The study revealed that the visual comfort of text reading was significantly impacted by indoor lighting[296]. Moreover, the participant's accuracy and speed of proof-reading were significantly impacted by their degree of proficiency, which in turn affected their visual perception and cognitive function/performance.

### 2.3.5 Contributions of IEQ Components on Wellbeing

According to the research on the effects of Indoor Environmental Quality (IEQ) on the performance of the staff in Building Technology department, a total of 216 copies of the questionnaire were distributed in the course of the study to the staff from six Nigerian post-secondary institutions. Data were gathered using a 38-item questionnaire, and three experts validated the instrument. Additionally, the instrument's internal consistency was checked using the Cronbach's Alpha reliability method, which yielded an internal consistency coefficient of 0.89. The data was analyzed using the t-test, mean, and standard deviation. The outcome of the study found that, improving indoor environmental quality has significant effects on staff performance, wellbeing, comfort, workspace utilization, and overall productivity[297].

In a related study conducted on the relationship between students' performance and Indoor Environmental Quality (IEQ) in air-conditioned university teaching rooms, both subjective assessments and objective measurements were used. The findings indicated that, there was a strong positive correlation between performance and IEQ[31]. Though, a poor and compromised IEQ had a negative impact on academic activities and learning. The study to investigate on whether a decline in the indoor environment quality may influence learners' overall performance through the numerical outcomes of tests that elementary school pupils obtain in their classrooms. Thus, questionnaires distributed to the same student samples were used to assess the parameters of indoor environmental quality, such as thermal, visual, acoustic and air quality, as well as to evaluate symptoms of Sick Building Syndrome (SBS). The findings revealed that parameters related to indoor environmental quality had a substantial impact on student performance[298].

Likewise, it demonstrated a strong negative association between the test scores and the IEQ components. The decline in IEQ components is therefore having an impact on pupils' performance.

**2.3.5.1 Thermal Comfort**

A study examining the effects of indoor air temperature on human thermal comfort, motivation, and performance comprising 36 students with a mean age of 23.3 years, who were divided into two groups was investigated. Group B, which included 16 participants was only exposed to a temperature of 26 °C. Group A, which included 20 subjects, was exposed to five different air temperatures: 22 °C, 24 °C, 26 °C, 29 °C and 32 °C. In each group, a self-reported motivation assessment using a 7-point rating system was administered. A warm, uncomfortable environment was found to impair wellbeing and decrease learning performance[299]. Environments with warmth discomfort had a greater detrimental effect on motivation and wellbeing than those with cold discomfort. Participants were more motivated as a result of an improvement in thermal comfort. Similarly, to examine the effects of higher temperature set-points during summer on office workers' cognitive load and thermal comfort, a sample of 26 male employees, aged between 31 and 50 and under 30, were exposed to 22 and 25 degrees Celsius. There were two test scores conducted. The planning skill was used to assess the subjects' competence in spatial planning, whereas the reasoning skill measured the subjects' ability for verbal reasoning. Temperature was shown to have little or no effect on the reasoning's or planning skills' test scores[300].

An investigation was done into the relationship between perceived air quality and cognitive performance at modestly elevated indoor temperatures, even when wearing comfortable clothing. Twelve participants, ranging in age from eighteen to thirty years old, were divided into two groups and subjected to two distinct temperatures of 23°C and

27°C. Computerized tests of typing performance, number computation, and grammar proficiency were given to each group. It was found that typing performance significantly diminished at higher temperatures when compared to lower temperatures[301]. As part of a study to investigate the effects of elevated body temperature on performance, reasoning, memory, and mood, twenty students were exposed to a core body temperature raised to 38.80–39.05°C within a few minutes by immersion in water at 41°C. Participants were asked to determine whether the statement correctly described the sequence of the letters in 16 simple logic problems. It was stated that there was no significant difference in accuracy performance across the several control experiments[302]. However, when the temperature rose, likewise did the performance speed.

In a bid to examine how the indoor thermal environment affects inhabitants' mental workload and task performance, 15 students, aged 22 to 33 were subjected into a climate chamber with three temperature settings: slightly cool, neutral, and slightly warm. Three options were provided in a number addition exercise to assess each subject's cognitive speed and alertness. It was stated that the subjects performed significantly differently under cool and warm circumstances for the hard-mode test[229]. In a study to examine productivity and fatique in a college environment, three operating temperatures (25.5 °C, 28 °C, and 33 °C) were experienced by 20 male and 20 female students. The tasks given to the subjects were code substitution, addition task, and a four-choice serial reaction time. It was said that among female students, there was no significant difference in performance across all three conditions on any of the tests. At 25°C, male students performed significantly worse compared to the other instances[303].

Research was performed to determine how SBS symptoms and office work performance were affected by moderate heat stress and open-plan office noise distraction. Thirty employees, comprising sixteen male and fourteen female office workers, were divided up into six groups. The testing room was adjusted to temperatures of 22 °C, 26 °C, and 30°C, with two noise levels of 35 dBA and 55dBA. Proof-reading was also employed to assess the reading comprehension of the subjects. The results showed that proof-reading performance dropped as the temperature increased in the same noise environment[299]. To assess the impact of indoor environment quality on productivity, 21 participants (6 females and 15 males) aged 18 to 20 years old were chosen as the study sample. The subjects were asked to complete tasks in three different indoor air temperatures (17°C, 21°C, and 28°C), and a verbal comprehension task was utilized to assess their reading comprehension. The carryover effects were modified for the measured performance. According to study, the reading comprehension performance with the highest accurate ratio at 21°C was recorded[299].

Additionally, the climate chamber experiment was carried out to assess the combined effects of lighting and heat on Iranian students' ability to concentrate. 33 students participated in the study, where they were subjected to 22°C and 37°C temperatures along with 200, 500, and 1500 lux lighting levels at the same 4500°C colour temperature. Conners Continuous Performance Test (CPT) was used to measure attention level, and an RT meter was used to assess reaction time (RT). By counting the number of errors and monitoring reaction time, the attention rate was ascertained. As a result, it found that, under the same lighting conditions, a rise in temperature was associated with an increase in commission error, omission error, response time, and decreased concentration[304].

As part of a research on how well students performed cognitively under temperature cycles brought on by direct load control events in the institution, students were placed in chamber settings and had their temperature modified by the air volume system from 16 to

38 degrees Celsius[209]. Eight distinct room temperature cycles were conducted. The background noise level was 40 ± 5 dBA, while the illumination was fixed at 500 lx. Tests of concentration and attention to detail were also performed. As a result, when the temperature rose more quickly, the concentration performance improved. The rate at which temperature changed was correlated with concentration performance[305].

Finally, a study involving 24 staff members was carried out to assess the productivity of office workers and the impact of room temperature. Four temperatures of 19, 24, 27 and 32 degrees Celsius were taken into consideration in an air-conditioned office with eight fluorescent lights. The study utilized the subjects' attention, performance on measures of letter search tests, memory span tests, and picture recognitions. The outcome confirmed that temperature had no influence on attention performance in any of the three tests involving response time and accuracy of outcomes[306].

**2.3.5.2 Indoor Air Quality**

A study sample of eighteen primary school students, aged ten to eleven, was utilized to examine the impact of lower ventilation on the cognitive function of the class. The $CO_2$ concentration was controlled in the study by opening and closing the window to adjust ventilation, and the subjects' level of concentration was assessed through task performance on a computerized cognitive assessment system. Higher $CO_2$ levels were observed to cause an approximate 5% decrease in the power of concentration and wellbeing, which in turn caused performance to diminish[307]. Research was also done on the neurobehavioral impacts of ambient air pollution on adult US citizens' cognitive function. According to ambient concentration in the Environmental Protection Agency (EPA) database, 1764 adults were exposed to $PM_{10}$ and ozone. The subjects were also given the opportunity to take the symbol-digit substitution test (SDST) to measure their coding abilities and the serial-digit learning test (SDLT) to test their attention. It was discovered that a lower task-performance score was connected to elevated exposure to indoor air pollution[308].

The study examined the relationship between perceived air quality, self-assessed acute health symptoms, and cognitive performance. Twenty-five students aged between 23 and 24, were subjected to five conditions mixed with three different $CO_2$ levels (500, 1000, and 3000 ppm) as well as varying concentrations of bio-effluent. The pupils were required to complete the D2 test, which was a paper-and-pencil test consisting of 14 rows of characters that were to be identified. The findings indicated that there were no statistically significant impacts of increasing $CO_2$ exposure on perceived air quality or attention performance. Additionally, exposure to bio-effluent thereby reduced the perceived air quality, decreased the number of correct connections produced in the cue-utilization test, lowered addition speed, and increased the degree of reported headache, weariness, sleepiness, and thinking difficulties[309].

In the study of air pollution and cognitive function in older individuals, 10,308 older adults (mean age 66 years) were utilized as a study sample. The annual average concentrations of $PM_{2.5}$ and $PM_{10}$ from 2003 to 2009 were examined using the Alice Heim 4-I test to assess reasoning performance. According to the study, low reasoning performance is associated with all particle metrics[310]. In the United States, research was conducted on the impacts of air pollution and fine particulate matter on cognitive performance in older adults. It was demonstrated that in an area with greater air quality, older people performed worse cognitively. As a result, cognitive performance declined as $PM_{2.5}$ concentration increased[310]. A cross-sectional relationship between dwelling $PM_{2.5}$ concentration and cognitive abilities was investigated. 13,996 older male seniors were interviewed through phone on their cognitive status. The experiment examined two independent cognitive functions: episodic memory and mental status. Similarly, 789 elderly women over the age of 55 were studied to determine the relationship between air pollution and cognitive abilities. The Mini-Mental State Examination (MMSE) and a cognition test from The Consortium to Establish a Registry for Alzheimer's Disease (CERAD)-Plus were used to assess exposure to $PM_{2.5}$ and nitrogen oxides. The outcome demonstrated a cross-sectional relationship between air pollution and a decline in wellbeing, satisfaction, comfort and performance in the CERAD total score due to a worse cognitive function[311].

**2.3.5.3 Noise/Acoustic**

The effects of open-plan office noise distraction and moderate heat stress on SBS symptoms and performance were studied in an office setting. The experiment room was adjusted to 22 °C, 26 °C, and 30 °C with two noise levels of 35 dBA and 55 dBA. Thirty workers were split into six groups. The creative thinking of the subjects was used to measure their performance. According to the study, there was a slight but non-significant difference in performance depending on the noise level[312]. An interview was conducted with 1,015 residents in the vicinity of Sydney Airport regarding their response to environmental noise. A structured interview evaluated noise-induced disturbance, demographic factors, reactions to noise, attitudes toward the noise source, sensitivity to noise, and physical and mental health issues. Measurements of aircraft noise were carried out at several homes close to flight paths. Thus, the findings indicated that airplane noise is associated with some noise-related symptoms like sleep and reading disturbances but not to anxiety or depression[313].

The impact of ambient noise on creative cognition was investigated in a different experiment. Under high, moderate, and low noise conditions of 85 dB, 70 dB, and 50 dB, respectively, 65 undergraduate students participated in Experiments 1 and 2, 95 students in Experiments 3 and 4, and 68 students in Experiment 5. The Remote Associates Test was employed to evaluate creative performance. It was discovered that moderate and low ambient noise levels improved performance on creative works. Moreover, better performance and wellbeing are enhanced in a moderately noisy environment compared to low, high, or control noise conditions[314].

In a study to investigate individual differences in susceptibility to the impacts of speech on reading comprehension, 40 students were chosen as the study sample. The speech that was irrelevant was recorded and played at a decibel level of about 7075 on headphones. The participants were instructed to sit in the quiet room and listen to the different speech fragments. The first five short texts were given to the students to read, and they had 90 seconds to respond to the accompanying questions. In the following fifteen texts, they had to choose one word from a list of four to build a sentence that was lacking one meaningful word. The study arrived at the conclusion that irrelevant speech interfered with reading comprehension but had no effect on task completion time[315].

Similar research was done with 158 undergraduate students to determine how the physical classroom setting affected their wellbeing and learning. It was noted that students who were not comfortable in the classroom seemed to be more negatively impacted by the noise level. Compared to students in the normal condition, the noise had a greater detrimental impact on their wellbeing and performance[316]. In another research, subjects were placed in two conditions: discomfort (26.7 °C, 60–65 dBA, and 2500 lx) and normal (22.2 °C, 35 dBA, and 500 lx). Prior to taking the assessment, the students had to read a test passage while the comprehension test employed the use of the Sentence Verification Task (SVT). According to a study on how noise and reverberation affect adults and children's speech perception and listening comprehension in a classroom-like environment, background noise has a far greater impact on listening comprehension[317]. Nonetheless, background noise had less of an impact on speech perception and performance than classroom noise performed. In the study, 94 adult participants/students, elementary school-aged children, 108 first-grade learners, and 149 third-grade students took part in the study. Two virtual classrooms were used for the experiment, with two reverberation times (RT) of 0.47 and 1.1 seconds for speech perception while for the listening comprehension, the task was performed in the room with classroom noise and background speech. To show a misunderstanding of the matter, students must listen to instructions and take the test.

A cross-sectional study on the effects of aircraft and road traffic noise on children's cognition and health was conducted. It was stated that there is a linear exposure-effect correlation between the aircraft exposure and traffic noise, which reduces wellbeing, learning performance and reading comprehension[318]. A total of 2844 students from three different countries, aged nine to ten were used as study samples. When conducting cognitive function tests, microphones were used to record sounds from passing cars and aircraft both inside and outside the classroom. Parents were asked to fill out a questionnaire about their child's perceived health, noise level, and annoyance. The Suffolk Reading Scale, the 10 CITO (Centraal Instituute Toets Ontwikkeling) readability index for elementary and special education, and the ECL-2 were the nationally standardized and normed tests used for reading comprehension in this study. Finally, in an additional study examining the impact of heat, noise, and indoor lighting on cognitive function, it was claimed that students performed better in low-noise environments than in high-noise ones[299]. The experiment was conducted in an off-white chamber that was equipped to resemble a neutral office of low-frequency noises of 38 and 58 dBA at 21 and 27°C temperatures and 300 and 1500 lux illumination respectively. After reading a seven-page text describing an ancient culture, the subjects, which consisted of 128 high school students between the ages of 18 and 19, had 130 minutes to complete 18 multiple-choice questions and six knowledge questions.

**2.3.5.4 Visual/Lighting**

In a study to investigate the impact of dynamic lighting on student learning, 84 pupils ranging in age from 7 to 8 were participated. Focus lighting (1000 lux, colour temperature 6500 K) and normal lighting (500 lux, colour temperature 3500 K) were the two lighting conditions employed in the study. Processing speed, rule compliance, and concentration performance were evaluated using the d2 test. It found that lighting had no influence on students' wellbeing, motivation or concentration in their performance[319]. Similarly, 32 individuals were divided into two standard light conditions to examine the effects of bright light on the working memory, attention, and concentration of elderly night shift workers. Sixteen employees were divided into two groups: one for bright light and the other for room light. They were required to complete three consecutive simulated night shifts under uniform settings. While the room light group worked at 300 lux every night, the bright light group was exposed to a moving light for four hours (3000 lux). Additionally, the Konzentrations-Leistungs-Test (KLT-R) for mental concentration and the Psychomotor Vigilance Test (PVT) for reaction time for sustained attention were carried out. According to the study, when performing a concentration performance task at night, exposure to bright light decreased error rates[320]. However, lighting had no obvious effect on how well a sustained attention test was performed.

Under the white LED desk lighting, the effects of correlated colour temperature on focused and sustained concentrations were investigated. 210 undergraduate students in total, ranging in age from 18 to 23 years. Chu Attention Test was used to measure three correlated colour temperatures (CCT): 2700 K, 4300 K, and 6500 K, all while keeping the same 500 lux of illumination. The test measures focused and sustained attention. Thus, it was demonstrated that correlated colour temperatures have a significant impact on concentration (CCT). Additionally, moderate condition of lighting greatly improves sustained and focused concentration[321]. Furthermore, twenty students were exposed to illuminance levels of 500 lx and 750 lx with light colour temperatures of 3000K, 4000K, and 6500K in the course of analyzing the occupants' visual perception to improve the indoor lighting environment for office tasks. The participants were given questionnaires about visual annoyance, such as those about tasks, visual satisfaction with light colors, and visual distraction. There were also computer-based and paper-based reading exercises to identify the letters in the paragraphs. When performing tasks in the office, the employees reported having improved and adequate visual perception or lighting[322].

According to research on how indoor lighting affects cognitive performance, students did better in high illumination environments than in low illumination conditions when participating in indoor tasks[323]. In the experiment, 128 high school students were placed in an off-white chamber with 300 and 1500 lux of illumination, set up like a neutral workplace. The task assigned to the students was to read a seven-page text about an ancient culture and provide answers to six multiple-choice questions and eighteen knowledge questions. A study examining the impact of indoor lighting on mood and cognitive function had 96 participants, ranging in age from 18 to 55 years. With two light color temperatures (3000 K and 4000 K) and two illuminance levels (300 lux and 1500 lux), the first experiment was full factorial and kept a high color rendering index (CRI) 95. The second experiment had the same set as the first, but with a lower colour rendering index (CRI) 55. As an encoding-retrieval task, the recognition task was evaluated using seven pages of compressed data related to an ancient culture. In precise, read the text and responded to six general knowledge questions and eighteen multiple-choice questions; the study concluded that a light colour temperature that produced the least negative mood improved the occupants' problem-solving skills and performance[324].

In a different study, 132 participants between the ages of 18 and 44 years were used to examine affective and cognitive responses to fluorescent lighting's unconscious flicker. Both traditional, magnetic, low-frequency ballasts (50 Hz) and dimmable, electronic, high-frequency ballasts (32000 Hz) are available. The study used three different types of fluorescent tubes with temperatures of 3000K, 4000K, and 5500K along with an embedded figure work. It follows that high frequency lighting is associated with a noteworthy improvement in problem solving performance[299]. Lastly, 158 college students, ages 17 to 49, participated in an investigation of how the physical classroom environment affects students' perceptions and learning. The conditions that the students were subjected to normal condition, characterized by 22.2°C, 35dBA, and 500 lx, and uncomfortable situation, which was 26.7°C, 60–65 dBA, and 2500 lx. After reading a test passage, the participants completed an assessment. The comprehension test was the Sentence Verification Task (SVT). According to the study, participants' listening or reading performance was unaffected by lighting[325].

### 2.3.6 Relationship between IEQ Components and Wellbeing

In the assessment of thermal comfort in view of creating high quality indoor ambience in the intelligent buildings was investigated. This is accomplished by combining objective survey measurements of relative humidity, air and globe temperatures, and carbon dioxide concentration at one and a half year intervals in 117 rooms alongside subjective measurements using 1369 questionnaires to evaluate thermal sensation, acceptability, and preference votes from the inhabitants. The outcome of the study revealed that, thermal comfort was the most critical factor in ensuring occupant health, performance and wellbeing in the intelligent buildings[254]. An investigation into the relationship between indoor environmental quality (IEQ) and the emergence of sick building syndrome (SBS) symptoms in the dormitories of Nigerian private university was carried out. The study adopted a field survey to measure 376 questionnaires that were purposefully distributed to hostel residents in addition to measuring IEQ factors objectively. Descriptive and inferential statistics using analysis of variance (ANOVA) were used for the collected data. The study revealed a positive and significant correlation between SBS symptoms such as nausea, stuffy nose, and odour and performance[122].

Additionally, in a study to investigate sick building syndrome and its impacts on health, productivity and wellbeing, the study used physical experiments and questionnaires to conduct field surveys, and the collected data was then subjected to multiple logistic regression modeling. The findings therefore established that symptoms of sick buildings and low productivity were significantly correlated with low thermal comfort, high work-related stress, excessive noise, a history of allergies or other medical conditions and poor lighting[326]. It was further discovered that there was a substantial correlation between general symptoms and age, temperature disruption, and work pressure. In Pokhara Metropolitan, Nepal, a cross-sectional study was conducted to establish the prevalence of sick building syndrome symptoms and related factors among bank employees. A field study questionnaire was distributed to commercial bank employees. The outcome of the findings showed that, there was a substantial correlation found between ocular symptoms and workplace noise disruption [327].

A cross-sectional field survey and a 24-hour mean assessment of air conditions using an air quality detector were used in the analysis of sick building syndrome (SBS) symptoms and indoor air pollution in homes and offices. The data was also analyzed using statistical tools like graphs, mean scores, analysis of variance (ANOVA), and correlation matrices.

The dataset was further analyzed using statistical tools like graphs, mean scores, analysis of variance (ANOVA), and correlation matrices. Thus, it was determined that there was a substantial correlation between the health symptoms of building inhabitants, wellbeing, productivity, and environmental indoor conditions such poor indoor air quality, loudness, lighting, headroom in the building, room space size, and window position[328]. To explore the relationship between SBS symptoms and indoor environmental quality, a Chi-square test was performed to examine the relationship between observed health, wellbeing productivity, and environmental variables. It was confirmed that there was no significant correlation found between indoor environmental quality (IEQ) and nasal, ocular, throat-related, or general SBS symptoms, but there was a statistically significant correlation established between productivity and skin-related SBS symptoms[329].

Subsequently, it was determined that a rise in perceived productivity and satisfaction with indoor air quality was positively significant associated with a decrease in the risk of sick building syndrome workspaces through the use of generalized estimating equation models to examine the relationship between perceived IEQ and SBS in an Asian multi-ethnic working population. However, there was no significant relationship found between workspace location and SBS[330]. Additionally, in a warm-humid hostel environment, the association between residents' self-reported health outcomes and performance and Indoor Air Quality (IAQ) was examined using Pearson correlation analysis. Further research demonstrated that the strongest association between occupants' physical health complaints and indoor air quality, specifically, indoor carbon dioxide and particle matter concentrations, is discovered[61].

In an effort to analyze the relationship between Sick Building Syndrome symptoms and occupants' perception of comfort with physical factors in offices at a public university in

Malaysia, a self-administered questionnaire to gather data and measurements of temperature, relative humidity, and air velocity were adopted. Multiple logistic regressions were performed using IBM Statistical Package for Social Science (SPSS) version 22.0 to analyze the data. The study found a substantial link between relative humidity, wellbeing, health problems (SBS), and staff productivity & comfort[331]. Moreover, the relationship between indoor environmental quality and sick building syndrome in an office building was evaluated. A modified questionnaire that was distributed to 154 office workers in conjunction with a Decision Tree (DT) model was adopted for the study. A strong correlation between productivity, indoor environmental quality component, and the prevalence of health complaints (SBS) was revealed as the outcome of the study [332].

The evaluation of correlations between SBS and indoor air quality in Chinese houses were examined. Both a self-administered questionnaire survey on occupants' health problems and a background assessment of building characteristics in 32 Chinese households were performed. According to the results, there is a substantial correlation between indoor air quality and productivity, wellbeing, satisfaction, and SBS symptoms of dry air and stuffy smells[333]. Lastly, a study examined the relationship between indoor contaminants, performance in learning, and health symptoms in elementary school-aged children and adults was conducted using measurements of indoor air pollutants from 128 homes in a cross-sectional study involving 184 elementary school children and 273 adults/adolescents in Japan. Result revealed that, dermal and mucosal health symptoms are strongly correlated with performance in both children and adults/adolescents[334].

## 2.4 Conceptual Framework

A conceptual framework presents an integrated way of looking at a research problem. It is a visual representation or narrative of the key variables or constructs of a research and the supposed relationship between them. It is argued that the entire methodology must agree with the variables, as well as their relationship and context. A conceptual framework therefore provides a logical structure of how to conduct the research as well as the variables that would explain the basic methodology for the research.

From the literature, numerous scholarly works had offered several conceptual frameworks to explain/contextualize research design through showing the relationship between the indicators, for assessing the objectives and the theories of the independent variables and the dependent variable. For instance, in a model to evaluate indoor environmental quality in dwelling homes and educational buildings through the adoption of both objective and subjective measurements, it was shown that, thermal comfort, indoor air quality, acoustics, and lighting as the key/primary variables of IEQ component affecting the degree of productivity and wellbeing of the occupants [335, 336].

Thus, this study is based on the assumption that evaluation of hostel rooms' indoor environmental quality (IEQ) on students' wellbeing can be assessed by identifying the IEQ components capable of providing information regarding the levels of influence on students' wellbeing. This study identified a number of indicators that influences wellbeing in the hostel rooms. Therefore, this approach leveraged on the IEQ component dimensions of thermal comfort, indoor air quality, visual/lighting and noise/acoustic conditions to develop a systematic analysis of most critical variables influencing students' wellbeing in the hostel rooms. An attempt has been made at integrating all these indicators and variables into a conceptual framework to explain the whole essence of the proposed research. The proposed conceptual framework for this study reflects four (4) key objectives. These objectives are: (i) the compass orientation of the hostel buildings and physical dimensions of the hostel rooms (ii) the adequacies of IEQ components of thermal comfort, IAQ, lighting and acoustic (iii) the satisfaction of the students with IEQ conditions and (iv) the impact of IEQ conditions on students' wellbeing.

Moreover, the variables for the first objective are the building geometry, number of rooms, number of loading, headroom, floor area, wall area, number of windows, size of windows, area of windows, building orientation, type of windows and window positions. The second objective has its variables as indoor rate of ventilation, Window/Floor Area Ratio and Window/Wall Area Ratio. Furthermore, the variables for the third objective are thermal sensation, preferences, sensations of air movement and humidity, satisfaction level with the indoor air quality, frequency in window openings, level of satisfaction with sound/noise, effects of noise on reading concentration, satisfaction level with overall lighting conditions, frequency in use of natural lighting etc while the last objective variables are level of students' wellbeing in the hostel rooms in relation to the levels of thermal comfort, indoor air quality, acoustic/ noise and visual/lighting.

However, based on the proposed conceptual framework for this study, it is assumed that the evaluation of hostel rooms' IEQ in selected universities in Oyo State, Nigeria are integrated within the most significant indicators/variables influencing the students' wellbeing in the study area.

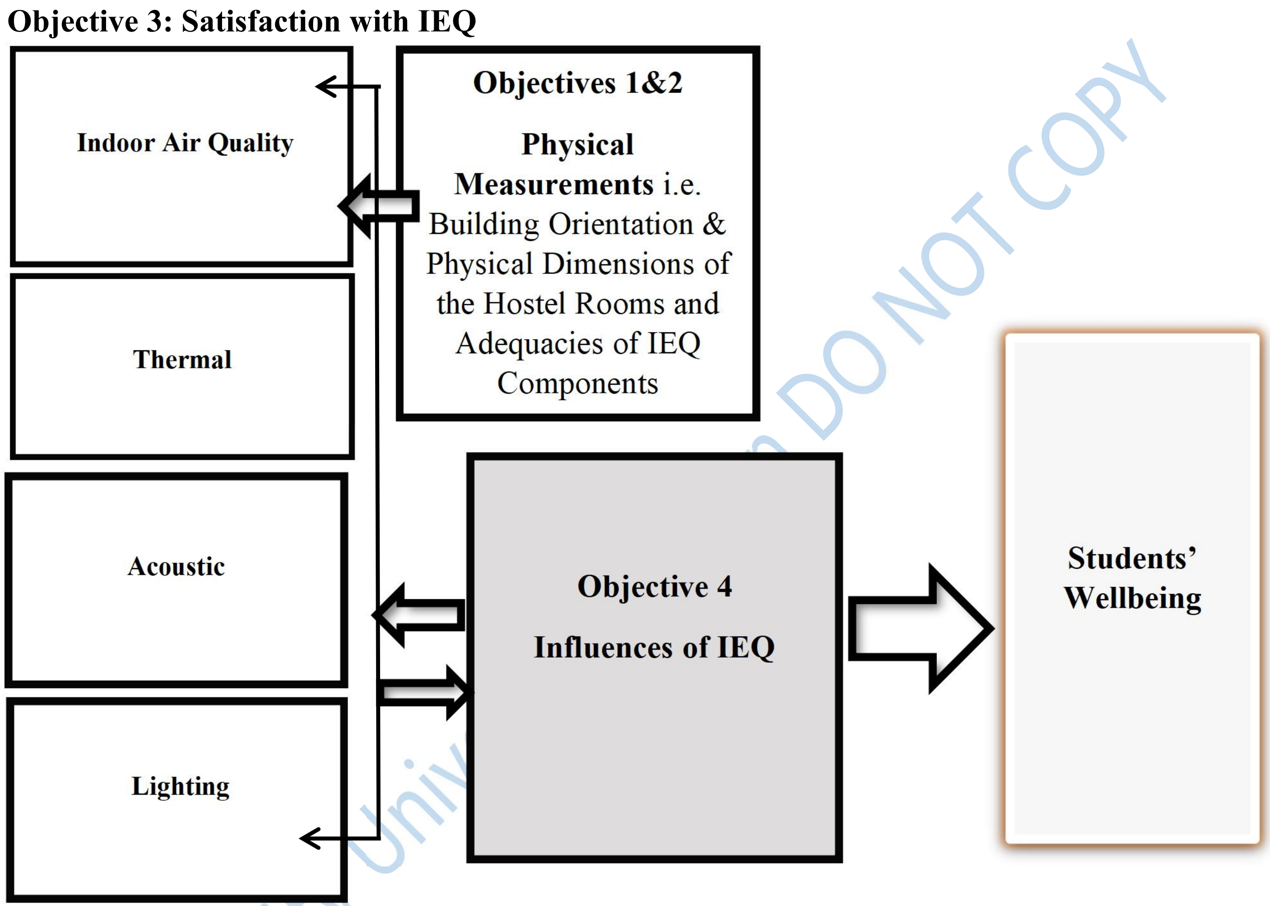



**Figure 2.8:** Researcher's Conceptual Model
**Source:** Researcher's Review, 2024

## 2.5 Summary of Gap in Literature Reviewed

The reviewed literature clearly stated that Indoor Environmental Quality (IEQ) has a significant impact on human life because inhabitants spend over two thirds of their everyday time indoors[337]. As such, this issue on university dormitories is important, given the fact that students constitute a huge population in any one building at any given moment. It had been discovered that, prior research was primarily concerned with IEQ and how it influenced individuals who were inhabitants of different building types, including workplaces, dwelling homes, classrooms, hospitals, etc., with less attention paid to the students' hostels in Nigeria. Moreover, only a limited number of IEQ research on students' halls of residence had been carried out [209].

Most of the studies on Indoor Environmental Quality assessments from the reviewed literature were focused only on objective measurements, based on chamber experiments, simulation, and modeling techniques. However, the technique of both subjective measurement, based on occupants' opinion (questionnaires) and objective measurement, based on orientation of the building and physical dimensions of the indoor spaces layout was rarely/infrequently used to assess the influence of IEQ on occupants' wellbeing.

While it has been discovered that the nature/quality of the indoor environment in which the students dwell has an impact on their wellbeing especially in hostels as one of the educational building facilities, there is also a vacuum in the literature about the influences of Indoor Environmental Quality (IEQ) on students' wellbeing in the dormitories around Nigeria and the entire globe [338, 339, 340]. Poor indoor environmental quality in hostels may lead to inhabitants developing diseases with a high risk factor, thus lowering their performance and wellbeing. As a consequence, another study found that the risk factor that results from having an unacceptable indoor environment might cause sick building syndrome[341]. This can then cause decline in the state of productivity and wellbeing[152]. Thus, it was further found that unfavourable indoor building environments raise the incidence of sick building syndrome and lower building inhabitants' productivity for reasoning, efficiency, satisfaction and wellbeing [326, 342].

With respect to the above, this study aimed to address the gaps in the literature regarding the influences of Indoor Environmental Quality (IEQ) on students' wellbeing. Specifically, it investigated the evaluation of IEQ components of hostel rooms on the wellbeing of students dwelling in hostels at Nigerian universities. Additionally, it explored the use of a questionnaire (subjective measurement) in combination with physical measurement (objective measurement) of hostel rooms to ascertain or validate the subjective feelings of the hostel occupants

## Endnotes


[1] M. Dovjak, A. Kukec, M. Dovjak & A. Kukec, "*Identification of Health Risk Factors and their Parameters,"* **Creating Healthy and Sustainable Buildings: An Assessment of Health Risk Factors**, 2019: 83-120.

[2] S. Sadrizadeh, R. Yao, F. Yuan, H. Awbi, W. Bahnfleth, Y. Bi, G. Cao, C. Croitoru, R. de Dear, F. Haghighat & P. Kumar, "*Indoor Air Quality and Health in Schools: A Critical Review for Developing the Roadmap for the Future School Environment*," **Journal of Building Engineering**, 2022: 104908.

[3] D. M. Stieb, G. J. Evans, T. M. To, P.S. Lakey, M. Shiraiwa, M. Hatzopoulou, M. Laura, J.F Brook, R.T. Burnett & S. A. Weichenthal, "*Within-City Variation in Reactive Oxygen Species from Fine Particle Air Pollution and COVID-19*," **American Journal of Respiratory and Critical Care Medicine**, 204, 2, 2021: 168-177.

[4] G.A. Ganesh, S.L. Sinha, T. N. Verma & S.K. Dewangan, "*Investigation of Indoor Environment Quality and Factors Affecting Human Comfort: A Critical Review*," **Building and Environment**, 204, 2021: 108-146.

[5] O. Toyinbo, "*Indoor Environmental Quality, Pupils' Health and Academic Performance: A Literature Review,*" **Buildings**, 13, 9, 2023: 2172.

[6] N. Mirzaei, H. Kamelnia, S.G. Islami, S. Kamyabi & S.N. Assadi, "*The Impact of Indoor Environmental Quality of Green Buildings on Occupants' Health and Satisfaction: A Systematic Review*," **Journal of Community Health Research**, 2020.

[7] M. Schweiker, E. Ampatzi, M.S. Andargie, R.K. Andersen, E. Azar, V.M. Barthelmes, C. Berger, L. Bourikas, S. Carlucci, G. Chinazzo & L.P. Edappilly, "*Review of Multi-Domain Approaches to Indoor Environmental Perception and Behaviour*," **Building and Environment**, 176, 2020: 106804.

[8] P.M. Bluyssen, *"Towards an Integrated Analysis of the Indoor Environmental Factors and its Effects on Occupants,"* **Intelligent Buildings International**, 12, 3, 2020: 199-207.

[9] A.M. Bueno, A.A. de Paula Xavier & E.E. Broday, "*Evaluating the Connection between Thermal Comfort and Productivity in Buildings: A Systematic Literature Review*," **Buildings**, 11, 6, 2021: 244.

[10] N.R. Kapoor, A. Kumar, T. Alam, A. Kumar, K.S. Kulkarni & P. Blecich, "*A Review on Indoor Environment Quality of Indian School Classrooms,*" **Sustainability**, 13, 21, 2021: 11855.

[11] P. Wargocki, J.A. Porras-Salazar, S. Contreras-Espinoza & W. Bahnfleth, "*The Relationships between Classroom Air Quality and Children's Performance in School*," **Building and Environment,** 173, 2020: 106749.

[12] S.S. Korsavi, A. Montazami & D. Mumovic, "*The Impact of Indoor Environment Quality (IEQ) on School Children's Overall Comfort in the UK: A Regression Approach*," **Building and Environment,** 185, 2020: 107309.

13. F. Mancini, F. Nardecchia, D. Groppi, F. Ruperto & C. Romeo, "*Indoor Environmental Quality Analysis for Optimizing Energy Consumptions Varying Air Ventilation Rates*," **Sustainability,** 12, 2, 2020: 482.

14. G.A. Ganesh, S.L. Sinha, T.N. Verma & S.K. Dewangan, "*Investigation of Indoor Environment Quality and Factors Affecting Human Comfort: A Critical Review,"* **Building and Environment,** 204, 2021: 108146.

15. S. Altomonte, J. Allen, P.M. Bluyssen, G. Brager, L. Heschong, A. Loder, S. Schiavon, J.A. Veitch, L. Wang & P. Wargocki, *"Ten Questions Concerning Well-Being in the Built Environment,"* **Building and Environment,** 180, 2020: 106949.

16. J. Gonzalez-Martin, N.J.R. Kraakman, C. Perez, R. Lebrero & R. Munoz, *"A State–of–the-Art Review on Indoor Air Pollution and Strategies for Indoor Air Pollution Control,"* **Chemosphere,** 262, 2021: 128376.

17 C. Riratanaphong & B. Chaiprasien, *"The Impact of Workplace Change of a Private Jet Company on Employee Satisfaction,"* **Facilities,** 38, 13/14, 2020: 943-960.

18 G. Lamberti, G. Salvadori, F. Leccese, F. Fantozzi & P.M. Bluyssen, "Advancement on thermal comfort in educational buildings: Current issues and way forward," **Sustainability**, 13, 18 (2021): 10315.

19. S. R. Perumal, F. Baharum & M.N.M. Nawi, *"Addressing Visual Comfort Issues in Healthcare Facilities Using LED Lighting Technology-A Review on Daylighting Importance, Impact of Correlated Colour Temperature, Human Responses and Other Visual Comfort Parameters,"* **Journal of Advanced Research in Fluid Mechanics and Thermal Sciences,** 82, 2, 2021: 47-60.

20. C. Wang, F. Zhang, J. Wang, J.K. Doyle, P.A. Hancock, C.M. Mak & S. Liu, *"How Indoor Environmental Quality Affects Occupants' Cognitive Functions: A Systematic Review,"* **Building and environment,** 193, 2021: 107647.

21 F. Yuan, R. Yao, S. Sadrizadeh, B. Li, G. Cao, S. Zhang, S. Zhou, H. Liu, A. Bogdan, C. Croitoru & A. Melikov, *"Thermal Comfort in Hospital Buildings: A Literature Review,"* **Journal of Building Engineering,** 45, 2022: 103463.

22. X. Shen, H. Zhang, Y. Li, K. Qu, L. Zhao, G. Kong & W. Jia, *"Building a Satisfactory Indoor Environment for Healthcare Facility Occupants: A Literature Review,"* **Building and Environment,** 2022: 109861.

23. Y. Xiao, B. Becerik-Gerber, G. Lucas & S.C. Roll, *"Impacts of Working from Home During COVID-19 Pandemic on Physical and Mental Well-Being of Office Workstation Users,"* **Journal of occupational and environmental medicine,** 63, 3, 2021: 181.

24. S. Roumi, F. Zhang, R.A. Stewart & M. Santamouris, *"Commercial Building Indoor Environmental Quality Models: A Critical Review,"* **Energy and Buildings,** 263, 2022: 112033

[25] F. Abass, L.H. Ismail, I.A. Wahab, W.A. Mabrouk & H. Kabrein, *"Indoor Thermal Comfort Assessment in Office Buildings in Hot-Humid Climate,"* In IOP Conference Series: Materials Science and Engineering, IOP Publishing, 2021: 12-29.

[26] A. Kaushik, M. Arif, P.Tumula & O.J. Ebohon, *"Effect of Thermal Comfort on Occupant Productivity in Office Buildings: Response Surface Analysis."* **Building and Environment,** 180, 2020: 107021.

[27] A. Bassoud, H. Khelafi, A.M. Mokhtari & A. Bada, *"Evaluation of Summer Thermal Comfort in Arid Desert Areas. Case Study: Old Adobe Building in Adrar (South Of Algeria),"* **Building and Environment,** 205, 2021: 108140.

[28] J. Kim, J. Ryu, B. Jeong & R. de Dear, *"Semantic Discrepancies between Korean and English Versions of The ASHRAE Sensation Scale,"* **Building and Environment,** 221, 2022: 109343.

[29] T. Mamani, R.F. Herrera, F. Muñoz-La Rivera & E. Atencio, *"Variables that Affect Thermal Comfort and Its Measuring Instruments: A Systematic Review,"* **Sustainability**, 14, 3, 2022: 1773.

[30] R. Yao, S. Zhang, C. Du, M. Schweiker, S. Hodder, B.W. Olesen, J. Toftum, F.R. d'Ambrosio, H. Gebhardt, S. Zhou & F. Yuan, *"Evolution and Performance Analysis of Adaptive Thermal Comfort Models: A Comprehensive Literature Review,"* **Building and Environment,** 217, 2022: 109020.

[31] N. R. Kapoor, A. Kumar, C.S. Meena, A. Kumar, T. Alam, N.B. Balam & A. Ghosh, *"A Systematic Review on Indoor Environmental Quality in Naturally Ventilated School Classrooms: A Way Forward,"* **Advances in Civil Engineering,** 2021, 2021: 1-19.

[32] C.C. Vassella, J. Koch, A. Henzi, A. Jordan, R. Waeber, R. Iannaccone & R. Charrière, *"From Spontaneous to Strategic Natural Window Ventilation: Improving Indoor Air Quality in Swiss Schools,"* **International Journal of Hygiene and Environmental Health,** 234, 2021: 113746

[33] L. Yang, S. Zhao, S. Gao, H. Zhang, E. Arens & Y. Zhai, *"Gender Differences in Metabolic Rates and Thermal Comfort in Sedentary Young Males and Females at Various Temperatures,"* **Energy and Buildings,** 251, 2021: 111360.

[34] L.G. Ioannou, K. Mantzios, L. Tsoutsoubi, S.R. Notley, P.C. Dinas, M. Brearley, Y. Epstein, G. Havenith, M.N. Sawka, P. Bröde & I.B. Mekjavic, *"Indicators to Assess Physiological Heat Strain–Part 1: Systematic Review,"* **Temperature,** 9, 3, 2022: 227-262.

[35] C.C. Munonye, P.N. Ohaegbu, I.N. Chukwu, O.C. Ifebi & C.N. Odimegwu, *"Upper Limit of Acceptable Temperature for Children in Naturally Ventilated Classrooms in Warm Humid Climate in Imo State, Nigeria,"* IOP Conference Series: Earth and Environmental Science, IOP Publishing, 2022: 012055

[36] A. Sharma & A. Kumar, *"Adaptive Thermal Comfort of Residential Buildings in the Composite Climatic Region of India: A Field Study,"* **Architectural Engineering and Design Management,** 2023: 1-22.

[37] L.A. Martins, V. Soebarto & T. Williamson, *"A Systematic Review of Personal Thermal Comfort Models,"* **Building and Environment,** 207, 2022: 108502.

[38] H. Du, Z. Lian, D. Lai, L. Duanmu, Y. Zhai, B. Cao, Y. Zhang, X. Zhou, Z. Wang, X. Zhang & Z. Hou, *"Evaluation of the Accuracy of PMV and Its Several Revised Models Using The Chinese Thermal Comfort Database,"* **Energy and Buildings,** 271, 2022: 112334.

[39] A.M. Bueno, A.A. de Paula Xavier & E.E. Broday, *"Evaluating the Connection between Thermal Comfort and Productivity in Buildings: A Systematic Literature Review,"* **Buildings,** 11, 6, 2021: 244.

[40] G. Lamberti, G. Salvadori, F. Leccese, F. Fantozzi & P.M. Bluyssen, *"Advancement on Thermal Comfort in Educational Buildings: Current Issues and Way Forward,"* **Sustainability,** 13, 18, 2021: 10315.

[41] B. Yang, P. Liu, Y. Liu, D. Jin & F. Wang, *"Assessment of Thermal Comfort and Air Quality of Room Conditions by Impinging Jet Ventilation Integrated With Ductless Personalized Ventilation,"* **Sustainability,** 14, 19, 2022: 12526.

[42] M.S.J. Talukdar, T.H. Talukdar, M.K. Singh, M.A. Baten & M.S. Hossen, *"Status of Thermal Comfort in Naturally Ventilated University Classrooms of Bangladesh in Hot and Humid Summer Season,"* **Journal of building engineering,** 32, 2020: 101700.

[43] A. Sharma & A. Kumar, *"Adaptive Thermal Comfort of Residential Buildings in the Composite Climatic Region of India: A Field Study,"* **Architectural Engineering and Design Management,** 2023: 1-22.

[44] H. Liu, X. Ma, Z. Zhang, X. Cheng, Y. Chen & S. Kojima, *"Study on The Relationship between Thermal Comfort and Learning Efficiency of Different Classroom-Types in Transitional Seasons in The Hot Summer and Cold Winter Zone of China,"* **Energies,** 14, 19, 2021: 6338.

[45] B. Lala & A. Hagishima, *"A Review of Thermal Comfort in Primary Schools and Future Challenges in Machine Learning Based Prediction for Children,"* **Buildings,** 12, 11, 2022: 2007.

[46] N. Sudarsanam & D. Kannamma, *"Investigation of Summertime Thermal Comfort at The Residences Of Elderly People in The Warm and Humid Climate of India,"* **Energy and Buildings,** 291, 2023: 113151.

[47] N.S.N. Khamis, R. Zainal, S.M.S. Musa & N. Kasim, *"Adaptation of Thermal Comfort in Naturally Ventilated Students Residential College in Tropical Climates of Malaysia,"* **International Journal of Engineering Technology Research & Management,** 5, 6, 2021: 151-158.

[48]. D.O. Oguntunde, F.M. Adedire, O.A. Alagbe & C.O, Anthony, *"Relationship between Indoor Thermal Conditions, Sleep Quality, Health and Performance in a Warm-Humid University's Students Hostel,"* **Archiculture,** 5, 1, 2023: 150-160.

\[49]. Z. Yang, W. Zhang, M. Qin & H. Liu, *"Comparative Study of Indoor Thermal Environment and Human Thermal Comfort in Residential Buildings among Cities, Towns, and Rural Areas in Arid Regions of China,"* **Energy and Buildings,** 273, 2022: 112373.

[50] A.K. Kaushik, M. Arif, M.M. Syal, M.Q. Rana, O.T. Oladinrin, A.A. Sharif & A.A.S. Alshdiefat, *"Effect of Indoor Environment on Occupant Air Comfort and Productivity in Office Buildings: A Response Surface Analysis Approach,"* **Sustainability,** 14, 23, 2022: 15719.

[51] F. Lolli, S. Marinello, A.M. Coruzzolo & M.A. Butturi, *"Post-Occupancy Evaluation's (POE) Applications for Improving Indoor Environment Quality (IEQ),"* **Toxics,** 10, 10, 2022: 626.

[52] H. Alzahrani, M. Arif, A.K. Kaushik, M.Q. Rana & H.M. Aburas, *"Evaluating the Effects of Indoor Air Quality on Teacher Performance Using Artificial Neural Network."* **Journal of Engineering, Design and Technology,** 21, 2, 2023: 604-618.

[53] S. Sadrizadeh, R. Yao, F. Yuan, H. Awbi, W. Bahnfleth, Y. Bi, G. Cao, C. Croitoru, R. de Dear, F. Haghighat & P. Kumar, *"Indoor Air Quality and Health in Schools: A Critical Review for Developing the Roadmap for the Future School Environment."* **Journal of Building Engineering,** 2022: 104908.

[54] J. Saini, M. Dutta & G. Marques, *"A Comprehensive Review on Indoor Air Quality Monitoring Systems for Enhanced Public Health,"* **Sustainable Environment Research,** 30, 1, 2020: 1-12.

[55] P. Kumar, A.B. Singh, T. Arora, S. Singh & R. Singh, *"Critical Review on Emerging Health Effects Associated with The Indoor Air Quality and Its Sustainable Management,"* **Science of The Total Environment,** 872, 2023: 162-163.

[56] R.M. Baloch, C.N. Maesano, J. Christoffersen, S. Banerjee, M. Gabriel, E. Csobod, É., de Oliveira Fernandes, I. Annesi-Maesano, P. Szuppinger, R. Prokai & P. Farkas, *"Indoor Air Pollution, Physical and Comfort Parameters Related to Schoolchildren's Health: Data from The European SINPHONIE Study,"* **Science of the Total Environment,** 739, 2020: 139870.

[57] V.B. Joseph, *Affect and the Workplace Built Environment,* Doctoral dissertation, University of Warwick, 2020.

[58] A. Kabirikopaei, *"A Data-Driven Study on the Association of Classrooms' Indoor Air Quality, Thermal Environment, and Students' Academic Performance"* Doctoral dissertation, The University of Nebraska-Lincoln, 2021.

[59] M. Schweiker, E. Ampatzi, M.S. Andargie, R.K. Andersen, E. Azar, V.M. Barthelmes, C. Berger, L. Bourikas, S. Carlucci, G. Chinazzo & L.P. Edappilly, *"Review of Multi-Domain Approaches to Indoor Environmental Perception and Behaviour,"* **Building and Environment,** 176, 2020: 106804.

[60] A. Monge-Barrio, M. Bes-Rastrollo, S. Dorregaray-Oyaregui, P. González-Martínez, N. Martin-Calvo, D. López-Hernández, A. Arriazu-Ramos & A. Sánchez-Ostiz, *"Encouraging Natural Ventilation to Improve Indoor Environmental Conditions at Schools: Case Studies in the North of Spain Before and During COVID,"* **Energy and Buildings**, 254, 2022: 111567.

[61] B.A. Orola, *"Seasonal Variations in Indoor Air Quality Parameters and Occupants Self-Reported Physical Health within a Warm Humid Climatic Environment,"* **Sustainable Buildings,** 5, 2020: 2.

[62] H.S. Abdulaali, I. Usman, M. Hanafiah, M. Abdulhasan, M. Hamzah & A. Nazal, *"Impact of Poor Indoor Environmental Quality (IEQ) to Inhabitants' Health, Wellbeing and Satisfaction,"* **International Journal of Advanced Science and Technology,** 29, 3, 2020: 1-14.

[63] M. Fakhari, V. Vahabi & R. Fayaz, *"A Study on the Factors Simultaneously Affecting Visual Comfort in Classrooms: A Structural Equation Modeling Approach,"* **Energy and Buildings,** 249, 2021: 111232.

[64] M. Kuhlenengel, I. Konstantzos & C.E. Waters, *"The Effects of the Visual Environment on K-12 Student Achievement,"* **Buildings,** 11, 11, 2021: 498.

[65] M.Y. Leung, L. Sieh & R. Yin, *"An Integrated Model for Luminous Environment and Quality of Life of Older People in Care and Attention Homes,"* **Building and Environment,** 2023: 110821.

[66] Z. Shen, X. Yang, C. Liu & J. Li, *"Assessment of Indoor Environmental Quality in Budget Hotels Using Text-Mining Method: Case Study of Top Five Brands in China,"* **Sustainability,** 13, 8, 2021: 4490.

[67] H.S. Abdulaali, M.M. Hanafiah, I.M. Usman, N.U.M. Nizam & M.J. Abdulhasan, *"A Review on Green Hotel Rating Tools, Indoor Environmental Quality (IEQ) and Human Comfort,"* **Int. Journal of Advanced Science and Technology,** 29, 3, 2020: 128-157.

[68] W.P. Akanmu, S.S. Nunayon & U.C. Eboson, *"Indoor Environmental Quality (IEQ) Assessment of Nigerian University Libraries: A Pilot Study,"* **Energy and Built Environment,** 2, 3, 2021: 302-314.

[69] P. Aderonmu, A. Adesipo, E. Erebor, A. Adeniji & O. Ediae, *"Assessment of Daylighting Designs in the Selected Museums of South-West Nigeria: A Focus on the Integrated Relevant Energy Efficiency Features,"* IOP Conference Series: Materials Science and Engineering, 640, 1, 2019: 012034.

[70] K.N. Fong, X. Ge, K.H. Ting, M. Wei & H. Cheung, *"The Effects of Light Therapy on Sleep, Agitation and Depression in People with Dementia: A Systematic Review and Meta-Analysis of Randomized Controlled Trials,"* **American Journal of Alzheimer's Disease & Other Dementias,** 38, 2023: 15333175231160682.

[71] I. Konstantzos, S.A. Sadeghi, M. Kim, J. Xiong & A. Tzempelikos, *"The Effect of Lighting Environment on Task Performance in Buildings: A Review,"* **Energy and Buildings,** 226, 2020: 110394.

[72] F. Jacob, S. John & D.M. Gwany, *"Teachers' Pedagogical Content Knowledge and Students' Academic Achievement: A Theoretical Overview,"* **Journal of Global Research in Education and Social Science,** 14, 2 (2020): 14-44.

[73] G. Chinazzo, J. Wienold & M.J.L.R. Andersen, *"Influence of Indoor Temperature and Daylight Illuminance on Visual Perception,"* **Lighting Research and Technology,** 52, 3, 2020: 350-370.

[74] W. Zhao, S. Kilpeläinen, R. Kosonen, J. Jokisalo, S. Lestinen, Y. Wu & P. Mustakallio,*"Human Response to Thermal Environment and Perceived Air Quality in an Office with Individually Controlled Convective and Radiant Cooling Systems,"* **Building and Environment,** 195, 2021: 107736.

[75] M. Alwetaishi, H. Al-Khatri, O. Benjeddou, A. Shamseldin, M. Alsehli, S. Alghamdi & R. Shrahily, *"An Investigation of Shading Devices in a Hot Region: A Case Study in a School Building,"* **Ain Shams Engineering Journal,** 12, 3, 2021: 3229-3239.

[76] N. Joshi & P. Patki, *"Relationship of Shading Devices and Its Effects on Daylight in Commercial Buildings in Pune,"* IOP Conference. Series of Earth Environmental Science, 1084, 2022: 012079

[77] A. Kumar, A. Kumar & K. Jain, *"Apps for Integrating Daylight with Artificial Lighting for Improving Building Energy Efficiency during Daytime in All Climates of India,"* Extracts from the Register of Copyrights, Copyright Office GOI, ROC-SW-12111/2019*,* 2019.

[78] R. Mokhtari, N. Dehghan & A. Maleki, "*Analysis of the Impact of Window Properties on the Main Living Space with the Aim of Daylight Efficiency and Energy Saving in the Hot and Dry Climate of Isfahan,"* **Journal of Solar Energy Research,** 8, 1, 2023: 1235-1249.

[79] K. Dokmeci, "*Investigation of Daylight in University Campus Buildings: İhsan Doğramaci Bilkent University and Mersin University,"* Master's thesis, Middle East Technical University, 2023.

[80] N. Castilla, J.L. Higuera-Trujillo & C. Llinares, *"The Effects of Illuminance on Students' Memory: A Neuroarchitecture Study,"* **Building and Environment,** 228, 2023: 109833.

[81] A. Ekmekci & D.M. Serrano, *"The Impact of Teacher Quality on Student Motivation, Achievement, and Persistence in Science and Mathematics,"* **Education Sciences,** 12, 10, 2022: 649.

[82] S. Hopkins, A.A. Black, S.L. White & J.M. Wood, *"Visual Information Processing Skills Are Associated with Academic Performance in Grade 2 School Children,"* **Acta ophthalmologica,** 97, 8, 2019: 1141-1148.

[83] J. Chen, H. Hu, H. Wu, Y. Jiang & C. Wang, *"Learning the Best Pooling Strategy for Visual Semantic Embedding,"* In Proceedings of the IEEE/CVF conference on computer vision and pattern recognition, 2021:15789-15798).

[84] F. Fantozzi & M. Rocca, *"An Extensive Collection of Evaluation Indicators to Assess Occupants' Health and Comfort in Indoor Environment,"* **Atmosphere,** 11, 1, 2020: 90.

[85] G. Di, Y. Wang, Y. Yao, J. Ma & J. Wu, *"Influencing Factors Identification and Prediction of Noise Annoyance—A Case Study on Substation Noise,"* **International Journal of Environmental Research and Public Health,** 19, 14, 2022: 8394.

[86]X. Shi, *"Environmental Health Perspectives for Low-and Middle-Income Countries,"* **Global Health Journal,** 6, 1, 2022: 35-37.

[87] M. Burfoot, A. Ghaffarianhoseini, N. Naismith & A. Ghaffarianhoseini, *"The Birth of Intelligent Passive Room Acoustic Technology: A Qualitative Review,"* **Smart and Sustainable Built Environment,** 12, 1, 2023: 60-83.

[88] C. van Reenen & D. Manley, *"Classroom Acoustics: Mainstreaming and Application of Standards,"* In Proceedings of Meetings on Acoustics, AIP Publishing, 51, 1. 2023.

[89] J. Mogas-Recalde, R. Palau & M. Márquez, *"How Classroom Acoustics Influence Students and Teachers: A Systematic Literature Review,"* **Journal of Technology and Science Education,** 11, 2, 2021: 245-259.

[90] G. Minelli, G.E. Puglisi & A. Astolfi, *"Acoustical Parameters for Learning in Classroom: A Review,"* **Building and Environment,** 208, 2022: 108582.

[91] I. Polewczyk & M. Jarosz, *"Teachers' and Students' Assessment of the Influence of School Rooms Acoustic Treatment on their Performance and Wellbeing,"* **Archives of Acoustics,** 45, 3, 2020: 401-417.

[92] A.M.O. Mohamed, E.K. Paleologos & F.M. Howari, *"Noise Pollution and Its Impact on Human Health and the Environment,"* ***In Pollution Assessment for Sustainable Practices in Applied Sciences and Engineering,*** 2021: 975-1026.

[93] X. Dong, Y. Wu, X. Chen, H. Li, B. Cao, X. Zhang, X. Yan, Z. Li, Y. Long & X. Li, *"Effect of Thermal, Acoustic, and Lighting Environment in Underground Space on Human Comfort and Work Efficiency: A Review,"* **Science of the Total Environment,** 786, 2021: 147537.

[94] C. Barksdale, M.L. Peters & A. Corrales, *"Middle School Students' Perceptions of Classroom Climate and Its Relationship to Achievement,"* **Educational Studies,** 47, 1, 2021: 84-107.

[95] M.S. Andargie, *Evaluating the Acoustic Performance of Multi-Unit Residential Buildings and the Associated Effects of Noise Exposure on Occupants' Comfort*, PhD Dissertation, University of Toronto, Canada, 2022.

[96] H.Tang, Y. Ding & B.C. Singer, *"Post-Occupancy Evaluation of Indoor Environmental Quality in Ten Nonresidential Buildings in Chongqing, China,"* **Journal of Building Engineering,** 32, 2020: 101649

[97] N. Suzuki, Y. Nakayama, H. Nakaoka, K. Takaguchi, K. Tsumura, M. Hanazato & C. Mori, *"Risk Factors for the Onset of Sick Building Syndrome: A Cross-Sectional Survey of Housing and Health in Japan,"* **Building and Environment,** 202, 2021: 107976.

[98] X. Huo, Y. Sun, J. Hou, P. Wang, X. Kong, Q. Zhang & J. Sundell, *"Sick Building Syndrome Symptoms among Young Parents in Chinese Homes,"* **Building and Environment,** 169, 2020: 106283.

[99] P. Kumar, A.B. Singh, T. Arora, S. Singh & R. Singh, *"Critical Review on Emerging Health Effects Associated with the Indoor Air Quality and Its Sustainable Management,"* **Science of the Total Environment,** 872, 2023: 162163.

[100] D.O. Nduka, K.D. Oyeyemi, O.M. Olofinnade, A.N. Ede & C. Worgwu, *"Relationship between Indoor Environmental Quality and Sick Building Syndrome: A Case Study of Selected Student's Hostels in South-Western Nigeria,"* **Cogent Social Sciences,** 7, 1, 2021: 1-17.

[101] M.T. Baeza_Romero, M.R. Dudzinska, M. Amouei Torkmahalleh, N. Barros, A.M. Coggins, D.G. Ruzgar, I. Kildsgaard, M. Naseri, L Rong, J. Saffell & A.M. Scutaru, *"A Review of Critical Residential Buildings Parameters and Activities when Investigating Indoor Air Quality and Pollutants,"* **Indoor air,** 32, 11, 2022: e13144.

[102] A.O. Afolabi, A. Arome & F.T. Akinbo, *"Empirical Study on Sick Building Syndrome from Indoor Pollution in Nigeria,"* **Open Access Macedonian Journal of Medical Sciences,** 8, E, 2020: 395-404.

[103] E. Tsantaki, E. Smyrnakis, T.C. Constantinidis & A. Benos, *"Indoor Air Quality and Sick Building Syndrome in a University Setting: A Case Study in Greece,"* **International Journal of Environmental Health Research,** 32, 3, 2022: 595-615.

[104] I.L. Niza, M.P. de Souza, I.M. da Luz & E.E. Broday, *"Sick Building Syndrome and Its Impacts on Health, Well-Being and Productivity: A Systematic Literature Review,"* **Indoor and Built Environment,** 33, 2, 2024: 218-236.

[105] S.M. Yussuf, G. Dahir & A.M. Salad, *"Sick Building Syndrome and Its Associated Factors among Adult People Living in Hodan District Moqadishu Somalia,"* **Age,** 18, 28, 2023:129.

[106] H.E. Sayan & S. Dulger, *"Evaluation of the Relationship between Sick Building Syndrome Complaints among Hospital Employees and Indoor Environmental Quality,"* **La Medicina del lavoro,** 112, 2, 2021:153.

[107] F. El Zein, & R. Hijazi, *"Poor Indoor Environmental Quality leading to Sick Building Syndrome,"* **International Journal of Multidisciplinary and Current Educational Research (IJMCER)***, 3, 6,* 2021:158-165.

[108] N. Aziz, M.A. Adman, N.S. Suhaimi, S. Misbari, A.R. Alias, A. Abd Aziz, L.F. Lee & M.M.H. Khan, *"Indoor Air Quality (IAQ) and Related Risk Factors for Sick Building Syndrome (SBS) at the Office and Home: A Systematic Review,"* In IOP Conference Series: **Earth and Environmental Science,** 1140, 1, 2023: 012007.

[109] A.M. Bueno, A.A. de Paula Xavier & E.E. Broday, *"Evaluating the Connection between Thermal Comfort and Productivity in Buildings: A Systematic Literature Review,"* **Buildings,** 11, 6, 2021: 244.

[110] P. Wolkoff, K. Azuma & P. Carrer, *"Health, Work Performance, and Risk Of Infection in Office-Like Environments: The Role of Indoor Temperature, Air Humidity, and Ventilation,"* **International Journal of Hygiene and Environmental Health,** 233, 2021: 113709.

[111] D. Khovalyg, O.B. Kazanci, H. Halvorsen, I. Gundlach, W.P. Bahnfleth, J. Toftum & B.W. Olesen, *"Critical Review of Standards for Indoor Thermal Environment and Air Quality,"* **Energy and Buildings,** 213, 2020: 109819.

[112] P. Wolkoff, *"Indoor Air Humidity Revisited: Impact on Acute Symptoms, Work Productivity, and Risk of Influenza and COVID-19 Infection,"* **International Journal of Hygiene and Environmental Health,** 256, 2024: 114313.

[113] S. Narubayeva, "*Evaluation of Indoor Environmental Quality in Sagkeeng Junior School*," Master's thesis, University of Manitoba Winnipeg, Manitoba, 2021.

[114] T.H. Kim, H. Lee, B.H. Choi & H.S. Hyun, *"A Pilot Study of Improving the Atmospheric Environment of Classroom for Students' Learning Activities,"* **Journal of People, Plants, and Environment,** 24, 2, 2021: 179-194.

[115] M.C. Albelda-Estellés Ness, *"Indoor Relative Humidity: Relevance for Health, Comfort, and Choice of Ventilation System,"* In Proceedings of 3rd Valencia International Biennial of Research in Architecture. Changing priorities. Valencia, 2022: 218-228. https://doi.org/10.4995/VIBRArch2022.2022.15237

[116] P.S. Nimlyat, Y.J. Inusa & P.K. Nanfel, *"A Literature Review of Indoor Air Quality and Sick Building Syndrome in Office Building Design Environment,"* **Green Building & Construction Economics,** 2023: 1-18.

[117] A. Ochoa-Aviles, A. Parra-Ullauri, M.J. Jaramillo-Torres, S. Escandon, M. Parra-Ullauri, D. Mejia, C. Ochoa-Aviles & C. Rodas-Espinoza, *"Indoor Environmental Quality in Pre-school Buildings in an Andean City in Ecuador."* **Journal of Green Building,** 19, 1, 2024: 177-204.

[118] A. Ackley, *"Measuring Indoor Environmental Quality (IEQ) in a National School Property Portfolio"* Doctoral dissertation, Open Access Te Herenga Waka-Victoria University of Wellington, 2021.

[119] Y.P.V. Arroyo, R. Peñabaena-Niebles & C.B. Correa, *"Influence of Environmental Conditions on Students' Learning Processes: A Systematic Review,"* **Building and Environment,** 231, 2023: 110051.

[120] Z.S. Zomorodian, M. Tahsildoost & M. Hafezi, *"Thermal Comfort in Educational Buildings: A Review Article,"* **Renewable and Sustainable Energy Reviews,** 59, 2016: 895-906.

[121] I. Sakellaris, D. Saraga, C. Mandin, Y. de Kluizenaar, S. Fossati, A. Spinazze, A. Cattaneo, V. Mihucz, T. Szigeti, E. de Oliveira Fernandes & K. Kalimeri, *"Association of Subjective Health Symptoms with Indoor Air Quality in European Office Buildings: The OFFICAIR Project,"* **Indoor Air,** 31, 2, 2021: 426-439.

[122] P.I.L.A.S. Swangsoonthonwes & S. Kesornthong, *"Sick Building Syndrome in a University Hospital in Thailand,"* Doctoral dissertation, Thammasat University, 2021.

[123] İ. Akova, E. Kiliç, H. Sumer & T. Keklikçi, *"Prevalence of Sick Building Syndrome in Hospital Staff and Its Relationship with Indoor Environmental Quality,"* **International Journal of Environmental Health Research**, 32, 6, 2022: 1204-1219.

[124] I.B. Zakaria & N. Mahyuddin, *"An Overview of Indoor Air Pollution in the Malaysian Kindergarten Environment,"* In IOP Conference Series: Earth and Environmental Science, 1013, 1, 2022: 012005.

[125] I.B. Zakaria & N. Mahyuddin, *"Indoor Air Quality (IAQ) in Malaysian Kindergarten: A Thematic Review,"* **International Journal of Real Estate Studies,** 16, S1, 2022: 47-55.

[126] M. Bhuda, J. Wichmann & J. Shirinde, *"Association between Outdoor and Indoor Air Pollution Sources and Atopic Eczema among Pre-school Children in South Africa,"* **International Journal of Environmental Research and Public Health,** 21, 3, 2024: 326.

[127] O. Itebimien, *"Ambient Air Quality Monitoring of an Educational Institution in Nigeria,"* **Coast Journal of the School of Science OAUSTECH Okitipupa,** 5, 1, 2023: 864-874.

[128] J. Wang, C. Janson, T. Gislason, M. Gunnbjörnsdottir, R. Jogi, H. Orru & D. Norbäck, *"Volatile Organic Compounds (VOC) In Homes Associated with Asthma and Lung Function among Adults in Northern Europe,"* **Environmental Pollution,** 321, 2023: 121103.

[129] S.D. Lowther, S. Dimitroulopoulou, K. Foxall, C. Shrubsole, E. Cheek, B. Gadeberg & O. Sepai, *"Low Level Carbon Dioxide Indoors: A Pollution Indicator or a Pollutant?. A Health-Based Perspective,"* **Environments,** 8, 11, 2021: 125.

[130] P.S. Nimlyat, B. Salihu & G.P. Wang, *"The Impact of Indoor Environmental Quality (IEQ) on Patients' Health and Comfort in Nigeria,"* **International Journal of Building Pathology and Adaptation,** 2022.

[131] M. Hu & H. Ming, *"Indoor Environmental Impact on Human Health,"* **Smart Technologies and Design for Healthy Built Environments,** 2021: 57-74.

[132] P.M. Bluyssen, *"Towards an Integrated Analysis of the Indoor Environmental Factors and Its Effects on Occupants,"* **Intelligent Buildings International,** 12, 3, 2020: 199-207.

[133] C.C. Munonye, *Thermal Comfort Assessment of Primary School Children in a Warm and Humid Climate: A Case Study of Imo State, Nigeria*, University of Salford: United Kingdom, 2020.

[134] U. Uotila & A. Saari, "*Determining Ventilation Strategies to Relieve Health Symptoms among School Occupants,"* **Facilities,** 41, 15/16, 2023: 1-20.

[135] A. Pacitto, L. Stabile, A. Frattolillo, A. Mikszewski, L. Morawska & G. Buonanno, *"Ventilation Strategies to Minimize the Airborne Virus Transmission in Indoor Environments."* In Proceedings of the 17th International Healthy Buildings Conference 21–23 June 2021, SINTEF, 2021: 369-378.

[136] E. Fazakas, I.A. Neamtiu & E.S. Gurzau, *"Health Effects of Air Pollutant Mixtures (Volatile Organic Compounds, Particulate Matter, Sulfur and Nitrogen Oxides): A Review of the Literature,"* **Reviews on Environmental Health,** 0, 2023.

[137] B. Adewale, F. Jegede, F. Okubote & M. Olagbadegun, *"Impact of Classroom Environments' on the Academic Performance of Architecture Students in Covenant University,"* In IOP Conference Series: **Earth and Environmental Science,** 665, 1, 2021: 012017.

[138] S. Caviola, C. Visentin, E. Borella, I. Mammarella & N. Prodi, *"Out of the Noise: Effects of Sound Environment on Maths Performance in Middle-School Students,"* **Journal of Environmental Psychology,** 73, 2021: 101552.

[139] R.K.A. Baafi, *"School Physical Environment and Student Academic Performance,"* **Advances in Physical Education,** 10, 2, 2020: 121-137.

[140] J. Whitlock, M. Kingan, C. Dykes, R. Gronert, C. Cliff & A. Ackley, *"Designing Schools in New Zealand (DSNZ): Designing Quality Learning Spaces (DQLS) Acoustics. Version 3.0, November 2020."* **The Journal of the Acoustical Society of America,** 154, 4, 2020: A214-A214.

[141] C. Clark, J. Head, M. Haines, I. van Kamp, E. van Kempen & S.A. Stansfeld, *"A Meta-Analysis of the Association of Aircraft Noise at School on Children's Reading Comprehension and Psychological Health for Use in Health Impact Assessment,"* **Journal of Environmental Psychology,** 76, 2021: 101646.

[142] H.W. Brink, M.G. Loomans, M.P. Mobach & H.S. Kort, *"Classrooms' Indoor Environmental Conditions Affecting the Academic Achievement of Students and Teachers in Higher Education: A Systematic Literature Review,"* **Indoor air,** 31, 2, 2021: 405-425.

[143] S. Porras Álvarez, *"Natural Light Influence on Intellectual Performance. A Case Study on University Students,"* **Sustainability,** 12, 10, 2020: 4167.

[144] R.M. Baloch, C. Nichole Maesano, J. Christoffersen, C. Mandin, E. Csobod, E. de Oliveira Fernandes, I. Annesi-Maesano & C. Sinphonie, *"Daylight and School Performance in European School-Children,"* **International Journal of Environmental Research and Public Health,** 18, 1, 2021: 258.

[145] M.C. Coronado, S. Feinberg, M. Fretz, A. Kwok, A. Gotlin, R. Greenheck, J. Lee, N. Pfeifer, J. Seely, N. Steeves & K. Van Den Wymelenberg, *The Impact of School Facilities on Student Learning and Engagement,* Eugene, Oregon: University of Oregon, 2021.

[146] P. Singh, R. Arora & R. Goyal, *"Impact of Lighting on Performance of Students in Delhi Schools,"* **In Indoor Environmental Quality:** Select Proceedings of the 1st ACIEQ, 2020: 95-108.

[147] C. Gabel, G. Elholm, S. Petersen & T. Sigsgaard, *"Seasonal Indoor Air Quality, Self-Reported Health and Comfort amongst Tenants Living at Danish Multi-Family Social Housing Sites,"* **Indoor and Built Environment**, 2024

[148] A. Zumelzu & M.G. Herrmann-Lunecke, *"Mental Wellbeing and the Influence of Place: Conceptual Approaches for the Built Environment for Planning Healthy and Walkable Cities,"* **Sustainability,** *13,* 11, 2021: 6395.

[149] M.J. Aransiola, "*Perceived Influence of Classroom Management Techniques on the Academic Performance of Business Studies Students in Secondary Schools in Kwara State, Nigeria,"* Master's Thesis, Kwara State University Nigeria, 2020.

[150] A. Cattaneo, A. Spinazze & D.M. Cavallo, "*Indoor Air Quality in Offices. In Handbook of Indoor Air Quality,"* **Singapore: Springer Nature Singapore,** 2022: 1935-1960.

[151] I. Donald, "*Environmental and Architectural Psychology:The Basics*," **Routledge,** 2022.

[152] V. Carrington, "*Rethinking Middle Years: Early Adolescents, Schooling and Digital Culture*. **Routledge,** 2020.

[153] S. Manca, V. Cerina, V. Tobia, S. Sacchi & F. Fornara, *"The Effect of School Design on Users' Responses: A Systematic Review (2008–2017),"* **Sustainability,** 12, 8, 2020: 3453.

[154] S. Ramani, K.D. Könings, S. Ginsburg & C.P. van der Vleuten, *"Meaningful Feedback through a Sociocultural Lens,"* **Medical Teacher,** 41, 12, 2019: 1342-1352.

[155] S.U. Amin, U. Ullah & M. Din, *"Assessing Window Design for Healing Environment in Selected Hospitals,"* **Annals of Human and Social Sciences,** 5, 2, 2024: 695-702.

[156] L. Wijnia, G. Noordzij, L.R. Arends, R.M. Rikers & S.M. Loyens, *"The Effects of Problem-Based, Project-Based, and Case-Based Learning on Students' Motivation: A Meta-Analysis,"* **Educational Psychology Review,** 36, 1, 2024: 29.

[157] E.M. Ireri, N. Mukirae & M. Otieno, *"Influence of Infrastructural Facilities and Staffing on Students' Academic Performance in National Secondary Schools in Kenya,"* **East African Journal of Education Studies,** 5, 2, 2022: 175-185.

[158] V. Onifade, *"The Effects of Residential Environmental Factors on Residents' Housing Satisfaction in Ogun State, Nigeria,"* **Ghana Journal of Geography,** 13, 2, 2021.

[159] H.D. Arslan & K. Yıldırım, *"Perceptual Evaluation of Traditional Turkish House Façade,"* **ICONARP International Journal of Architecture and Planning,** 2021.

[160] F. Gbadegesin, L. Marais, J. Cloete, K. Rani, M. Lenka, M. Serekoane, M. Boivin, C. Shohet, D. Givon & C. Sharp, *"Housing, Home and Children's Socio-Emotional Health: Conceptual Ideas and Empirical Evidence from a South African Pilot Study,"* **Housing, Theory and Society,** 39, 5, 2022: 555-572.

[161] T. Putnam, *"The Art of Home-Making and the Design Industries. In Contemporary Art and the Home,"* **Routledge,** 2020: 75-92.

[162.] L.T. Larsen, *"Not Merely the Absence of Disease: A Genealogy of The WHO's Positive Health Definition,"* **History of the Human Sciences,** 35, 1, 2022: 111-131.

[163.] Z. Ebrahimi, H. Patel, H. Wijk, I. Ekman & P. Olaya-Contreras, *"A Systematic Review on Implementation of Person-Centered Care Interventions for Older People in Out-of-Hospital Settings,"* **Geriatric Nursing**, 42, 1, 2021: 213-224.

[164] ·M. Dooris, S. Kokko & E. de Leeuw, *"Evolution of the Settings-Based Approach," In Handbook of Settings-Based Health Promotion,* Cham: Springer International Publishing, 2022: 3-22.

[165.] H.H. Nguye & H.V. Tran, *"Digital Society and Society 5.0: Urgent Issues for Digital Social Transformation in Vietnam,"* **Masyarakat, Kebudayaan & Politik,** 35, 1, 2022.

[166] ·F. Thomas, T. Kain, & G.B. Monica, *"27 The Spiritual Dimension of Health,"* **One Health: The Theory and Practice of Integrated Health Approaches,** 2020: 356.

[167] E.M. Taylor, N. Robertson, C.J. Lightfoot, A.C. Smith & C.R. Jones, *"Nature-Based Interventions for Psychological Wellbeing in Long-Term Conditions: A Systematic Review,"* **International Journal of Environmental Research and Public Health**, 19, 6, 2022: 3214.

[168.] K. Wan, Z. Feng, S. Hajat & R.M. Doherty, *"Temperature-Related Mortality and Associated Vulnerabilities: Evidence from Scotland Using Extended Time-Series Datasets,"* **Environmental Health,** 21, 1, 2022: 1-14.

169. L. He, B. Xue, B. Wang, C. Liu, D.G.R. de Porras, G.L. Delclos, H. Ming, L. Bin & K. Zhang, *"Impact of High, Low, and Non-Optimum Temperatures on Chronic Kidney Disease in a Changing Climate, 1990–2019: A Global Analysis,"* **Environmental Research,** 212, 2022: 113172.

170. M.J. Roos, B.M. Snijders & C.J. Keijsers, *"Incidence of Infection as the Underlying Cause for Hypothermia in Older Patients at the Emergency Department,"* **Journal of the American Geriatrics Society,** 2023.

171. S. Tham, R. Thompson, O. Landeg, K.A. Murray & T. Waite, *"Indoor Temperature and Health: A Global Systematic Review,"* **Public Health,** 179, 2020: 9-17.

172. T. Kubozono, Y. Akasaki, S. Kawasoe, S. Ojima, T. Kawabata, H. Makizako, S. Kuwahata, T. Takenaka, M. Maeda, M. Ohno & M. Kijimuta, *"The Relationship between Home Blood Pressure Measurement and Room Temperature in a Japanese General Population,"* **Hypertension Research,** 44, 4, 2021: 454-463.

173. V. Ingole, S.C. Sheridan, S. Juvekar, H. Achebak & P. Moraga, *"Mortality Risk Attributable to High and Low Ambient Temperature in Pune City, India: A Time Series Analysis from 2004 to 2012,"* **Environmental Research,** 204, 2022: 112304.

174. G. Cil & J. Kim, *"Extreme Temperatures During Pregnancy and Adverse Birth Outcomes: Evidence from 2009 to 2018 US National Birth Data,"* **Health Economics,** 31, 9, 2022: 1993-2024.

175. A. Bouchama, B. Abuyassin, C. Lehe, O. Laitano, O. Jay, F.G. O'Connor & L.R. Leon, *"Classic and Exertional Heatstroke,"* **Nature Reviews Disease Primers,** 8, 1, 2022: 8.

176. M.F. Chersich, M.D. Pham, A. Areal, M.M. Haghighi, A. Manyuchi, C.P. Swift, B. Wernecke, M. Robinson, R. Hetem, M. Boeckmann & S. Hajat, *"Associations between High Temperatures in Pregnancy and Risk of Preterm Birth, Low Birth Weight, and Stillbirths: Systematic Review and Meta-Analysis,"* **Bmj,** 371, 2020.

177. S. Fahad, & J. Wang, *"Climate Change, Vulnerability, and Its Impacts in Rural Pakistan: A Review,"* **Environmental Science and Pollution Research,** 27, 2020: 1334-1338.

178. S.C. Anenberg, S. Haines, E. Wang, N. Nassikas & P.L. Kinney, *"Synergistic Health Effects of Air Pollution, Temperature, and Pollen Exposure: A Systematic Review of Epidemiological Evidence,"* **Environmental Health**, 19, 2020: 1-19.

179. V. Iyakaremye, G. Zeng, X. Yang, G. Zhang, I. Ullah, A. Gahigi, F. Vuguziga, T.G. Asfaw & B. Ayugi, *"Increased High-Temperature Extremes and Associated Population Exposure in Africa by the Mid-21st Century,"* **Science of the Total Environment,** 790, 2021: 148162.

180. A.S. Adegoke, C.A. Ajayi, T.T. Oladokun & T.O. Ayodele, *"A Post-Occupancy Evaluation of Students' Halls of Residence in Obafemi Awolowo University, Ile-Ife, Nigeria,"* **Property Management,** 39, 2, 2021: 163-179.

181. I.A. Liman, *"Performance Evaluation of Public Secondary School Hostel Buildings in Niger State,"* **International Journal of Environmental Design & Construction Management,** 20, 4, 2021: 139-151.

182. C.E. Leslie, *"Interaction Patterns and Support for Learning in the Primary Foreign Language Classroom."* **Porta Linguarum Revista Interuniversitaria de Didáctica de las Lenguas Extranjeras,** 36, 2021: 65-82.

183. K.A. Reynolds, J. Sommer, C.S. Mackenzie & L. Koven, *"A Profile of Social Participation in a Nationally Representative Sample of Canadian Older Adults: Findings from the Canadian Longitudinal Study on Aging,"* **Canadian Journal on Aging/La Revue canadienne du vieillissement,** 41, 4, 2022: 505-513.

184 L. Gabbianelli & T. Pencarelli, *"On-Campus Accommodation Service Quality: The Mediating Role of Students' Satisfaction on Word of Mouth,"* **The TQM Journal,** 2023.

185. R.A. Aderonke, *"Influence of Socio-Economic Factors on Students' Academic Performance in Business Education, Kwara State University."* **KWASU International Journal of Education (KIJE),** 5, 1, 2022: 177-187.

186. F.R. Khan, A. Shekili, N. Said, A.S. Al Badi & H.A. Al Khanbashi, *"Exploring the Impact of Hostel Life of Students on Academic Performance: Sohar University: A Case Study."* **International Journal of Research in Entrepreneurship & Business Studies,** 1, 1, 2020: 1-14.

187. Y.A.K. Al-Taee & M.K.A.M. Sulaiman, *"Indoor Environmental Comfort in Student Hostel at Malaysia's Public University: A Literature Review,"* **Jurnal Kejuruteraan,** 33, 3, 2021: 487-501.

188. A. Boissonneault & T. Peters, *"Concepts of Performance in Post-Occupancy Evaluation Post-Probe: A Literature Review,"* **Building Research & Information,** 51, 4, 2023: 369-391.

189. A. Jobi, B. Ogunbodede & S. Tongo, *"Design Characteristics and Crime Experience in University Students' Halls of Residence,"* **Kufa Journal of Engineering,** 13, 4, 2022: 1-12.

190. B.M.A. Khaznadar & S.Y. Bapir, *"Sustainable Continuity of Cultural Heritage: An Approach for Studying Architectural Identity Using Typo-Morphology Analysis and Perception Survey,"* **Sustainability,** 15, 11, 2023: 9050.

191 I.L. Niza, A.M. Bueno & E.E. Broday, "*Indoor Environmental Quality (IEQ) and Sustainable Development Goals (SDGs): Technological Advances, Impacts and Challenges in the Management of Healthy and Sustainable Environments,"* **Urban Science,** 7, 2023: 96.

192 S.A. Istil, J. Górecki & A. Diemer, "*Study on Certification Criteria of Building Energy and Environmental Performance in the Context of Achieving Climate Neutrality,"* **Sustainability**, 15, 2023: 2770.

[193] A.K. Al Harazi, W. Zhang, S.A.A. Shah, A.A.M.H. Al Asbahi, Y.K. Al Harazi & S.Y. Alwan, *"Multidimensional Study of Factors Influencing Sustainable Construction Adoption in Yemen: Insights for Implementing Sustainable Practices"* **Environ. Sci. Pollut. Res. Int.** 30, 2022: 20650–20672.

[194] Y. Jung, K. Park & J. Ahn, *"Sustainability in Higher Education: Perceptions of Social Responsibility among University Students"* **Social Science**, 8, 2019: 90.

[195] T.H. Jasimin & R.C. Amat, *"Modelling the Relationship between IEQ towards Economic Aspect of Sustainability for Malaysian Green Commercial Office Building Using Structural Equation Modelling Technique"* **Malays. Constr. Res. Journal,** 6, 2019: 65–75.

[196] L.A. Bugenings & A. Kamari, *"Bioclimatic architecture strategies in Denmark: A Review of Current and Future Directions"* **Buildings,** 12, 2022: 224.

[197] K. Xhexhi, *"In the Traces of Bioclimatic Architecture. In Ecovillages and Ecocities; The Urban Book Series"* Springer: Cham, Switzerland, 2023.

[198] A. Deslatte, S. Kim, C.V. Hawkins & E. Stokan, *"Keeping Policy Commitments: An Organizational Capability Approach to Local Green Housing Equity"* **Rev. Policy Res**. 2022.

[199] F. Lolli, A.M. Coruzzolo & E. Balugani, *"The Indoor Environmental Quality: A TOPSIS-Based Approach with Indirect Elicitation of Criteria Weights"* **Saf. Sci.,** 148, 2022: 105652.

[200] A. Eweda, A. Al-Sakkaf, T. Zayed & S. Alkass, *"Condition Assessment Model of Building Indoor Environment: A Case Study on Educational Buildings,"* **Int. J. Build. Pathol. Adapt.** 41, 2023: 767–788.

[201]F. Lolli, S. Marinello, A.M. Coruzzolo & M.A. Butturi, *"Post-Occupancy Evaluation's (POE) Applications for Improving Indoor Environmental Quality (IEQ),"* **Toxics,** 10, 2022: 626.

[202]S.A. Abdel-Razek, H.S. Marie, A. Alshehri & O.M. Elzeki, *"Energy Efficiency through the Implementation of an AI Model to Predict Room Occupancy Based on Thermal Comfort Parameters,"* **Sustainability,** 14, 2022: 7734.

[203] A.A.S. Abdelazim, M. Abdelaal & W. Mohamed, *"Towards Sustainable Buildings Using Building Information Modelling as a Tool for Indoor Environmental Quality and Energy Efficiency: In Proceedings of the WIT Transactions on The Built Environment,"* WIT Press: Southampton, UK, 2021.

[204] F. Leccese, M. Rocca, G. Salvadori, E. Belloni & C. Buratti, *"Towards a Holistic Approach to Indoor Environmental Quality Assessment: Weighting Schemes to Combine Effects of Multiple Environmental Factors,"* **Energy Build.** 245, 2021: 111056.

[205]A. Asojo, H. Vo & S. Bae, *"The Impact of Design Interventions on Occupant Satisfaction: A Workplace Pre-and Post-Occupancy Evaluation Analysis,"* **Sustainability,** 13, 2021: 13571.

[206] M. Ortiz, L. Itard & P.M. Bluyssen, *"Indoor Environmental Quality Related Risk Factors with Energy-Efficient Retrofitting of Housing: A Literature Review,"* **Energy Build.** 221, 2020: 110102.

[207] E.S. Dalampira & S.A. Nastis, *"Mapping Sustainable Development Goals: A Network Analysis Framework,"* **Sustainable Development,** 28, 2020: 46–55.

[208] E.E. Empig, A. Sivacioglu, R.S. Pacaldo, P.D. Suson, R.Q. Lavilles, M.R.Y. Teves, M.C.M. Ferolin & R.F. Amparado, *"Climate Change, Sustainable Forest Management, ICT Nexus, and the SDG 2030: A Systems Thinking Approach,"* **Sustainability,** 15, 2023: 6712.

[209] R. Sperry & G. Bender, *"Airport Buildings: A Key Opportunity for Sustainability in Aviation,"* **Journal Air. Management,** 14, 2020: 234–245.

[210] I. Calvo, A. Espin, J.M. Gil-García, P. Fernández Bustamante, O. Barambones & E. Apiñaniz, *"Scalable IOT Architecture for Monitoring IEQ Conditions in Public and Private Buildings,"* **Energies,** 15, 2022: 2270.

[211]E. Attaianese, F. d'Ambrosio Alfano, B. Palella, D. Pepe & R. Vanacore, *"An Integrated Methodology of Subjective Investigation for a Sustainable Indoor Built Environment. The Case Study of a University Campus in Italy,"* **Atmosphere,** 12, 2021: 1272.

[212]S. Nurick & A. Thatcher, *"Enhanced Indoor Environmental Quality and the Link to Individual Productivity and Organisational Performance: A Scoping Review,"* **J. Afr. Real Estate Res.** 6, 2022: 83–115.

[213] S.L. Navy, "*Theory of Human Motivation: Abraham Maslow,"* **Science Education in Theory and Practice: An Introductory Guide to Learning Theory,** 2020: 17-28.

[214] M.L. Recker, "*Social and Emotional Learning Defined through Exploration of Albert Bandura's Social Cognitive Theory and Abraham Maslow's Hierarchy of Needs: A Document Analysis of Ohio's K-12 Social and Emotional Learning Standards and Theory Alignment,"* Doctoral Dissertation, University of Findlay**,** 2023.

[215] G.C. Thangaswamy, J. Arulappan, S. Anumanthan & S.K. Jayapal, *"Trends and Determinants of Mental Health during COVID-19 Pandemic: Implications and Strategies to Overcome the Mental Health Issues: A Rapid Review from 2019-2020,"* **International Journal of Nutrition, Pharmacology, Neurological Diseases,** *11*, 1, 2021: 1-6.

[216] K.E. Dickard, *"Who Puts the "Support" in Supportive Housing? The Impact of Housing Staff on Resident's Well-Being, and the Potential Moderating Role of Self-Determination,"* Master's thesis, Portland State University, 2023.

[217] F. Saba Sadeghpour, *"Effects of Physical Environmental Design Attributes on Psychological Well-being of College Students in University Dormitory during the Covid-19 Pandemic Period,"* **Architectural Research,** 24*,* 4, 2022: 105-111.

[218] S. Altomonte, J. Allen, P.M. Bluyssen, G. Brager, I. Heschong, A. Loder, S. Schiavon, J.A. Veitch, L. Wang & P. Wargocki, *"Ten Questions Concerning Wellbeing in the Built Environment,"* **Building and Environment,** *180*, 2020: 106949.

[219]A. Riva, A. Rebecchi, S. Capolongo & M. Gola, *"Can Homes Affect Wellbeing? A Scoping Review among Housing Conditions, Indoor Environmental Quality, and Mental Health Outcomes,"* **International Journal of Environmental Research and Public Health,** 19, 23, 2022: 15975.

[220] C.C. Johnson, S.L. Havstad, D.R. Ownby, C.L. Joseph, A.R. Sitarik, J.B. Myers, J. B. & J.E. Gern,*"Pediatric Asthma Incidence Rates in the United States from 1980 to 2017,"* **Journal of Allergy and Clinical Immunology,** 148, 5, 2021: 1270-1280.

[221] Y. Choi, D.J. Yoon, J.D. Lee & J.Y.E. Lee, *"Relationship Conflict and Counter-Productive Work Behavior: The Roles of Affective Wellbeing and Emotional Intelligence,"* **Review of Managerial Science,** 18, 4, 2024: 1129-1148.

[222] J. Pandey, M. Kumar & S. Singh, *"Organizational Ethical Climate: Influence on Employee Meaning and Wellbeing,"* **Management Decision,** 2024.

[223] W.C. Zou, J.D. Houghton & J.J. Li, *"Workplace Spirituality as a means of Enhancing Service Employee Wellbeing through Emotional Labor Strategy Choice,"* **Current Psychology**, 41, 8, 2022: 5546-5561.

[224] L. Heschong, "*Visual Delight in Architecture: Daylight, Vision, and View*," **Routledge**, 2021.

[225] A. Engineer, R.J. Gualano, R.L.Crocker, J.L., Smith, V. Maizes, A. Weil & E.M. Sternberg, *"An Integrative Health Framework for Wellbeing in the Built Environment,"* **Building and Environment,** 205, 2021: 108253.

[226] A.H. Khan, S. Sultana, S. Hossain, M.T. Hasan, H.U. Ahmed & M.T. Sikder, *"The Impact of COVID-19 Pandemic on Mental Health and Wellbeing among Home-Quarantined Bangladeshi Students: A Cross-Sectional Pilot Study,"* **Journal of Affection Disorder,** 277, 2020: 121–128

[227] M. Franke & C. Nadler, *"Towards a Holistic Approach for Assessing the Impact of IEQ on Satisfaction, Health, and Productivity,"* **Building Research and Information,** 49, 4, 2021: 417-444.

[228] W. He, J. Qiu, A. Fu & D. Zheng, *"The Effect of Residential Mobility on the Intention of Social Environment Exploration for Emerging Adults,"* **Current Psychology,** 2021: 1-6.

[229] Y. Duan & J. Wu, *"Sport Tourist Perceptions of Destination Image and Revisit Intentions: An Adaption of Mehrabian-Russell's Environmental Psychology Model,"* **Heliyon,** 2024.

[230] S. Dlamini & S.G. Tesfamichael, *"Approaches on the Concepts of Place Attachment in South Africa,"* **GeoJournal,** 86, 5, 2021: 2435-2445.

[231] B.R. Meagher, *"Ecologizing Social Psychology: The Physical Environment as a Necessary Constituent of Social Processes,"* **Personality and Social Psychology Review,** 24, 1, 2020: 3-23.

[232] M. Pulimeno, P. Piscitelli, S. Colazzo, A. Colao & A. Miani, *"Indoor Air Quality at School and Students' Performance: Recommendations of the UNESCO Chair on Health Education and Sustainable Development & the Italian Society of Environmental Medicine (SIMA),"* **Health Promotion Perspectives,** 10, 3, 2020: 169.

[233] S.G. Wood, A.E. Handy, K. Roberts & H.C. Burridge, *"Assessing Classroom Ventilation Rates using $CO_2$ Data from a Nationwide Study of UK Schools and Identifying School-wide Correlation Factors,"* **Developments in the Built Environment,** 2024: 100520.

[234] A. Wolska, D. Sawicki & M. Tafil-Klawe, "*Visual and Non-visual Effects of Light: Working Environment and Well-Being*," CRC Press, 2020.

[235] E.S. Lee, B.S. Matusiak, D. Geisler-Moroder, S.E. Selkowitz & L. Heschong, *"Advocating for View and Daylight in Buildings: Next Steps,"* **Energy and Buildings,** 265, 2022: 112079

[236] L. Zhang & H. Ma, *"The Effects of Environmental Noise on Children's Cognitive Performance and Annoyance,"* **Applied Acoustics,** 198, 2022: 108995.

[237] M.B. McClain, S.E. Yoho, R.B. Drill, C.R. Haverkamp, S.E. Schwartz, B.A. Barker, D.N. Longhurst & S.R. Upton, *"Reading Skills and Background Noise in Autistic and Non-autistic Children: A Pilot Study,"* **Contemporary School Psychology,** 2023: 1-13.

[238] C.A. Hviid, C. Pedersen & K.H. Dabelsteen, *"A Field Study of the Individual and Combined Effect of Ventilation Rate and Lighting Conditions on Pupils' Performance,"* **Building and Environment,** 171, 2020: 106608.

[239] W.C. Sullivan & D. Li, *"Nature and Attention,"* **Nature and Psychology: Biological, Cognitive, Developmental, and Social Pathways to Well-Being,** 2021: 7-30.

[240] R. Nagare, M. Woo, P. MacNaughton, B. Plitnick, B. Tinianov & M. Figueiro, *"Access to Daylight at Home Improves Circadian Alignment, Sleep, and Mental Health in Healthy Adults: A Cross-over Study,"* **International Journal of Environmental Research and Public Health,** 18, 19, 2021: 9980.

[241] O.B. Ayoko, N.M. Ashkanasy, Y. Li, A. Dorris & K.A. Jehn, *"An Experience Sampling Study of Employees' Reactions to Noise in the Open-Plan Office,"* **Journal of Business Research,** 155, 2023:113445.

[242] J.A. Porras-Salazar, F. Tartarini & S. Schiavon, *"The Effect of Indoor Temperature on Work Performance of Fifty-Eight People in a Simulated Office Environment,"* **Building and Environment,** 263, 2024: 111813.

[243] L.A. Martins, V. Soebarto & T. Williamson, *"A Systematic Review of Personal Thermal Comfort Models,"* **Building and Environment,** 207, 2022: 108502.

[244] L.A. Martins, T. Williamson, H. Bennetts, J. Zuo, R. Visvanathan, A. Hansen, D. Pisaniello, J. Hoof & V. Soebarto, *"Individualising Thermal Comfort Models for Older People: The Effects of Personal Characteristics on Comfort and Wellbeing,"* In 2020 Windsor Conference, 2020:187-199.

[245] M. Shrestha, H.B. Rijal, G. Kayo & M. Shukuya, *"A Field Investigation on Adaptive Thermal Comfort in School Buildings in the Temperate Climatic Region of Nepal,"* **Building and Environment,** 190, 2021: 107523.

[246] P. Aparicio-Ruiz, E. Barbadilla-Martin, J. Guadix & J. Munuzuri, *"A Field Study on Adaptive Thermal Comfort in Spanish Primary Classrooms during Summer Season,"* **Building and Environment,** 203, 2021: 108089.

[247] C.C. Munonye, O.C. Ifebi, C.N. Odimegwu, I.N. Chukwu & P.N. Ohaegbu, *"Comparative Analysis of Comfort Temperature of Children and their Teachers,"* **Only One Earth,** 2022: 406.

[248] Z. Yang, W. Zhang, M. Qin & H. Liu, *"Comparative Study of Indoor Thermal Environment and Human Thermal Comfort in Residential Buildings among Cities, Towns, and Rural Areas in Arid Regions of China,"* **Energy and Buildings,** 273, 2022: 112373.

[249] N.S.N. Khamis, R. Zainal, S.M.S. Musa & N. Kasim, *"Adaptation of Thermal Comfort in Naturally Ventilated Students Residential College in Tropical Climates of Malaysia,"* **International Journal of Engineering Technology Research & Management,** 5, 6, 2021: 151-158.

[250] S. Kumar, A. Mathur, M.K. Singh & K.B. Rana, *"Adaptive Thermal Comfort Study of Workers in a Mini-Industrial Unit during Summer and Winter Season in a Tropical Country, India,"* **Building and Environment,** 197, 2021: 107874.

[251] S. Subhashini, T. Kesavaperumal & M. Noguchi, *"An Adaptive Thermal Comfort Model for Naturally Ventilated Classrooms of Technical Institutions In Madurai,"* **Open House International,** 46, 4, 2021: 682-696.

[252] A.B. Sholanke, M.O. Faleti & K.C. Ukaigwe, *"Users' Perception of Comfort Experienced in Academic Buildings of Selected Universities in Ogun State, Nigeria,"* In IOP Conference Series: **Earth and Environmental Science,** 1054, 1, 2022:.012026.

[253] C. Munonye & Y. Ji, *"Evaluating the Perception of Thermal Environment in Naturally Ventilated Schools in a Warm and Humid Climate in Nigeria,"* **Building Services Engineering Research and Technology,** 42, 1, 2021: 5-25.

[254] G. Majewski, Ł.J. Orman, M. Telejko, N. Radek, J. Pietraszek & A. Dudek, *"Assessment of Thermal Comfort in the Intelligent Buildings in View of Providing High Quality Indoor Environment,"* **Energies,** 13, 8, 2020: 1973.

[255] M. Bughio, T. Schuetze & W.A. Mahar, *"Comparative Analysis of Indoor Environmental Quality of Architectural Campus Buildings' Lecture Halls and Its' Perception by Building Users, in Karachi, Pakistan,"* **Sustainability,** 12, 7, 2020: 2995.

[256]A.K. Ayinla & I.I. Adebisi, *"Investigating Indoor Ventilation in Multi-Habited Houses: A Case of Ogbomoso, Nigeria,"* **International Journal of Civil Engineering, Construction and Estate Management,** 9, 3, 2021: 1-15.

[257] Z. El Akili, Y. Bouzidi, A. Merabtine, G. Polidori & A. Chkeir, *"Experimental Investigation of Adaptive Thermal Comfort in French Healthcare Buildings,"* **Buildings,** 11, 11, 2021: 551.

[258] J.N. Offor, *"Investigation of the Influence of Natural Ventilation on Indoor Comfort of Occupants of Public Hospital Wards within the Hot-Humid Climates,"* **Irish International Journal of Engineering and Applied Sciences,** 6, 2, 2022.

[259] M.U. Adaji, T.O. Adekunle & R. Watkins, *"Overheating and Passive Cooling Strategies in Low-Income Residential Buildings in Abuja, Nigeria,"* In Routledge Handbook of Resilient Thermal Comfort, **Routledge**, 2022: 159-174.

[260] S. Kumar & M.K. Singh, *"Seasonal Comfort Temperature and Occupant's Adaptive Behaviour in a Naturally Ventilated University Workshop Building under the Composite Climate of India,"* **Journal of Building Engineering,** 40, 2021: 102701.

[261] F. Reza & S. Kojima, *"Thermal Comfort Investigation Based Design Considerations for the Tropical Studio Type Classroom,"* **Int. Journal of Sustainable Development and Planning,** 15, 8, 2020: 1179-1185.

[262] H.H. Al-Kayiem, M.N. Mohammed, K. Kelly, T.W. Riyadi & M. Effendy, *"Experimental Assessment and Development of Thermal Comfort Model for Implication in Tropical Climate,"* **International Journal of Computational Methods and Experimental Measurements,** 11, 1, 2023: 35-43.

[263] A.E. Ejiga, *"Assessment of Thermal Comfort in Some Selected Lecture Rooms in Gidan-Kwano Campus,"* PhD dissertation, Federal University of Technology Minna, 2023.

[264] A.A. Kunle, A.I. Ismail, O.O. Adedayo & A.E. Oloruntoba, *"Thermal Indices Influence on Occupants' Window Opening Behaviours: A case of Ibadan and Ogbomoso, Oyo State, Nigeria,"* **Journal of Architectural Environment & Structural Engineering Research,** 4, 1, 2021: 18-27.

[265] J.O. Faremi, P.O. Kukoyi, U.E. Edike, A.S. Sotunbo, O.A. Adenuga & H.A. Koleoso, *"Energy Performance Benchmarking in University of Lagos Hostel Buildings,"* **Energy,** 10, 2, 2023.

[266] M. Indraganti, F. Kutty, R. Ali, L. Al Noaimi, S. Al-Bader & M.A. Al Mulla, *"Occupant Perception of Thermal Comfort in Sleep Environments in Qatar,"* **The Journal of Engineering Research (TJER),** 18, 2, 2021: 137-145.

[267]A. Audu, P. Nimlyat, A. Jimoh, A. Umaru & M.M. Bello*, "A Comparative Analysis of Subjective Thermal Comfort Perception in Selected Residential Building Typologies in Jos-Nigeria,"* **coou African Journal of Environmental Research,** 5, 1, 2024: 109-130.

[268] L. Dębska, *"Assessment of the Indoor Environment in the Intelligent Building,"* **Civil and Environmental Engineering,** 17, 2, 2021: 572-582.

[269] J.Y. Lee, P. Wargocki, Y.H. Chan, L. Chen & K.W. Tham, *"How Does Indoor Environmental Quality in Green Refurbished Office Buildings Compare with the One in New Certified Buildings?"* **Building and Environment,** 171, 2020: 106677.

[270] I. Yuki, "*The Effect of Survey Scale Sizes on How People Assess the Effect of the Built Environment on their Work Performance."* PhD Dissertation, Open Access Te Herenga Waka-Victoria University of Wellington, 2020.

[271] E.P. Dam-Krogh, R.F. Rupp, G. Clausen & J. Toftum, *"Scoping Review of Post Occupancy Evaluation of Office Buildings with Focus on Indoor Environmental Quality and Productivity,"* **Journal of Building Engineering,** 2024: 108911.

[272] D. Horvath & F. Borgonovi, *"Global Warming, Pollution and Cognitive Developments: The Effects of High Pollution and Temperature Levels on Cognitive Ability Throughout the Life Course,"* **OECD Social, Employment and Migration Working Papers,** 269, 2022: 1-68.

[273] J.H. Park, T.J. Lee, M.J. Park, H. Oh & Y.M. Jo, *"Effects of Air Cleaners and School Characteristics on Classroom Concentrations of Particulate Matter in 34 Elementary Schools in Korea,"* **Building and Environment,** 167, 2020: 106437.

[274] D. Zhang, E. Ding & P.M. Bluyssen, *"Guidance to Assess Ventilation Performance of a Classroom Based on $CO_2$ Monitoring,"* **Indoor and Built Environment,** 31, 4, 2022: 1107-1126.

[275] P. Wargocki & J.A. Porras-Salazar, *"The Relationships between Classroom Air Quality and Children's Performance in School,"* **Building and Environment,** 173, 2020: 106749.

[276] R. Gupta, A. Howard & S. Zahiri, *"Investigating the Relationship between Indoor Environment and Workplace Productivity in Naturally and Mechanically Ventilated Office Environments,"* **Building Services Engineering Research and Technology,** 41, 3, 2020: 280-304.

[277] L. Bergefurt, M. Weijs-Perrée, R. Appel-Meulenbroek & T. Arentze, *"The Physical Office Workplace as a Resource for Mental Health: A Systematic Scoping Review,"* **Building and Environment,** 207, 2022: 108505.

[278] K. Mealings, "Classroom acoustics and cognition: *A Review of the Effects of Noise and Reverberation on Primary School Children's Attention and Memory,"* **Building Acoustics,** 29, 3, 2022: 401-431.

[279] J. Radun, M. Lindberg, A. Lahti, M. Veermans, R. Alakoivu & V. Hongisto, *"Pupils' Experience of Noise in Two Acoustically Different Classrooms,"* **Facilities,** 41, 15/16, 2023: 21-37.

[280] N. Bhandari, S. Tadepalli & P. Gopalakrishnan, "*Investigation of Acoustic Comfort, Productivity, and Engagement in Naturally Ventilated University Classrooms: Role of Background Noise and Students' Noise Sensitivity,"* **Building and Environment,** 249, 2024: 111131.

[281] R. Thompson, R.B. Smith, Y.B. Karim, C. Shen, K. Drummond, C. Teng & M.B. Toledano, *"Noise Pollution and Human Cognition: An Updated Systematic Review and Meta-Analysis of Recent Evidence."* **Environment International,** 158, 2022: 106905.

[282] K. Mealings, *"A Scoping Review of the Effect of Classroom Acoustic Conditions on Primary School Children's Numeracy Performance and Listening Comprehension,"* **Acoustics Australia,** 51, 1, 2023: 129-158.

[283] G. Rance, R.C. Dowell & D. Tomlin, *"The Effect of Classroom Environment on Literacy Development,"* **npj Science of Learning,** 8, 1, 2023: 9.

[284] Z.U.R. Farooqi, I. Ahmad, A. Ditta, P. Ilic, M. Amin, A.B. Naveed & A. Gulzar, *"Types, Sources, Socio-Economic Impacts, and Control Strategies of Environmental Noise: A Review,"* **Environmental Science and Pollution Research,** 29, 54, 2022: 81087-81111.

[285] C. Martinez-Perez, C. Alvarez-Peregrina, R. Brito, M.A. Sanchez-Tena & O.I.L. Grupo de Investigação, *"The Evolution and the Impact of Refractive Errors on Academic Performance: A Pilot Study of Portuguese School-Aged Children,"* **Children,** 9, 6, 2022: 840.

[286] M. Lekan-Kehinde & A. Asojo, *"Impact of Lighting on Children's Learning Environment: A Literature Review,"* **WIT Trans. Ecol. Environment,** 253, 2021: 371-380.

[287] W. Yang & J.Y. Jeon, *"Effects of Correlated Colour Temperature of LED Light on Visual Sensation, Perception, and Cognitive Performance in a Classroom Lighting Environment,"* **Sustainability,** 12, 10, 2020: 4051.

[288] A. Baba, I. Shahrour & M. Baba, *"Indoor Environmental Quality for Comfort Learning Environments: Case Study of Palestinian School Buildings,"* **Buildings,** 14, 5, 2024: 1296.

[289] J. Mogas-Recalde & R. Palau, *"Classroom Lighting and Its Effect on Student Learning and Performance: Towards Smarter Conditions,"* Proceedings of the 5th International Conference on Smart Learning Ecosystems and Regional Development, 2021: 3-12.

[290] R. Mahfoudh & N. Ghabra, *"Study of Active Design Strategies to Enhance Physical Activity in University Educational Buildings: A Case Study at King Abdulaziz University,"* **Journal of Umm Al-Qura University for Engineering and Architecture,** 14, 4, 2023: 241-270.

[291]A.A. Freewan & J.A. Al- Dalala, *"Assessment of Daylight Performance of Advanced Daylighting Strategies in Large University Classrooms: Case Study Classrooms at JUST,"* **Alexandria Engineering Journal,** 59, 2, 2020: 791-802.

[292] N.S. Shafavi, Z.S. Zomorodian, M. Tahsildoost & M. Javadi, *"Occupants Visual Comfort Assessments: A Review of Field Studies and Lab Experiments,"* **Solar Energy,** 208, 2020: 249-274.

[293] L. Mason, A. Ronconi, S. Scrimin & F. Pazzaglia, *"Short-Term Exposure to Nature and Benefits for Students' Cognitive Performance: A Review,"* **Educational Psychology Review,** 34, 2, 2022: 609-647.

[294] V. López-Chao, A. Amado Lorenzo, J.L. Saorín, J. De La Torre-Cantero & D. Melián-Díaz, *"Classroom Indoor Environment Assessment through Architectural Analysis for the Design of Efficient Schools,"* **Sustainability,** 12, 5, 2020: 2020.

[295] M. Schweiker, E. Ampatzi, M.S. Andargie, R.K. Andersen, E. Azar, V.M. Barthelmes, C. Berger, L. Bourikas, S. Carlucci, G. Chinazzo & L.P. Edappilly, *"Review of Multi-Domain Approaches to Indoor Environmental Perception and Behaviour,"* **Building and Environment,** 176, 2020: 106804.

[296] Q. Liu, Z. Huang, Z. Li, M.R. Pointer, G. Zhang, Z. Liu, H. Gong & Z. Hou, *"A Field Study of the Impact of Indoor Lighting on Visual Perception and Cognitive Performance in Classroom,"* **Applied Sciences,** 10, 21, 2020: 7436.

[297] A. Okanya, J. Asogwa & I. Onyedikachi, *"Indoor Environmental Quality (IEQ) in Nigerian Tertiary Institutions: The Effect on Performance of Building Technology Lecturers,"* **Middle Eastern Journal of Research in Education and Social Sciences,** 2, 1, 2021: 172-186.

[298] R.L. Hwang, W.J. Liao & W.A. Chen, *"Optimization of Energy Use and Academic Performance for Educational Environments in Hot-Humid Climates,"* **Building and Environment,** 222, 2022: 109434.

[299] C. Wang, F. Zhang, J. Wang, J.K. Doyle, P.A. Hancock, C.M. Mak & S. Liu, *"How Indoor Environmental Quality Affects Occupants' Cognitive Functions: A Systematic Review,"* **Building and Environment,** 193, 2021: 107647.

[300] C. Sun, Y. Han, L. Luo & H. Sun, *"Effects of Air Temperature on Cognitive Work Performance of Acclimatized People in Severely Cold Region in China,"* **Indoor and Built Environment,** 30, 6, 2021: 816-837.

[301] L. Lan, J. Tang, P. Wargocki, D.P. Wyon & Z. Lian, *"Cognitive Performance was Reduced by Higher Air Temperature even when Thermal Comfort was Maintained Over the 24–28 $^{0}$C Range,"* **Indoor Air,** 32, 1, 2022: e12916.

[302] P. Wolkoff, K. Azuma & P. Carrer, *"Health, Work Performance, and Risk of Infection in Office-Like Environments: The Role of Indoor Temperature, Air Humidity, and Ventilation,"* **International Journal of Hygiene and Environmental Health,** 233, 2021: 113709.

[303] J. Hu, Y. He, X. Hao, N. Li, Y. Su & H. Qu, *"Optimal Temperature Ranges Considering Gender Differences in Thermal Comfort, Work Performance, and Sick Building Syndrome: A Winter Field Study in University Classrooms,"* **Energy and Buildings,** 254, 2022: 111554..

[304] Z. Mohebian, H. Dehghan & M. Hoseinbore, *"Investigating the Effects of Different Levels of Lighting on the Attention Index of Male and Female: An Experimental Study,"* **International Journal of Environmental Health Engineering,** 12, 5, 2023: 24.

[305] W. Liu, X. Tian & M. Tao, *"A Model to Quantify the Relation between Cognitive Performance and Thermal Responses in High Temperature at a Moderate Activity Level,"* **Building and Environment,** 207, 2022: 108431.

[306] X. Fan & Y. Zhu, *"Effects of Indoor Temperature on Office Workers' Performance: An Experimental Study Based on Subjective Assessments, Neurobehavioral Tests, and Physiological Measurements,"* **Ergonomics,** 2023: 1-15.

[307] S.S. Korsavi, A. Montazami & D. Mumovic, *"Perceived Indoor Air Quality in Naturally Ventilated Primary Schools in the UK: Impact of Environmental Variables and Thermal Sensation,"* **Indoor air,** 31, 2, 2021: 480-501.

[308] W. Lu, D.A. Hackman & J. Schwartz, *"Ambient Air Pollution Associated with Lower Academic Achievement among US Children: A Nationwide Panel Study of School Districts,"* **Environmental epidemiology,** 5, 6, 2021: e174.

[309] D. Chen, G. Huebner, E. Bagkeris, M. Ucci & D. Mumovic, *"Effects of Exposure to Moderate Pure Carbon Dioxide Levels on Cognitive Performance, Acute Health Symptoms and Perceived Indoor Environment Quality,"* **Acute Health Symptoms and Perceived Indoor Environment Quality,** 2023.

[310] C. Mac Domhnaill, O. Douglas, S. Lyons, E. Murphy & A. Nolan, *"Road Traffic Noise and Cognitive Function in Older Adults: A Cross-Sectional Investigation of the Irish Longitudinal Study on Ageing,"* **BMC Public Health,** 21, 2021: 1-14.

[311] H. Altug, K.B. Fuks, A. Hüls, A.K. Mayer, R. Tham, J. Krutmann & T. Schikowski, *"Air Pollution is Associated with Depressive Symptoms in Elderly Women with Cognitive Impairment,"* **Environment International,** 136, 2020: 105448.

[312] D. Khovalyg, C.A. Berquand, G. Vergerio, V.M. Barthelmes, A. Chatterjee, C. Becchio & D. Licina, *"Energy, SBS Symptoms, and Productivity in Swiss Open-Space Offices: Economic Evaluation of Standard, Actual, and Optimum Scenarios,"* **Building and Environment,** 242, 2023: 110565.

[313] R. Thompson, R.B. Smith, Y.B. Karim, C. Shen, K. Drummond, C. Teng & M.B. Toledano, *"Noise Pollution and Human Cognition: An Updated Systematic Review and Meta-Analysis of Recent Evidence,"* **Environment International,** 158, 2022: 106905.

[314] M. Awada, B. Becerik-Gerber, G. Lucas & S. Roll, *"Cognitive Performance, Creativity and Stress Levels of Neuro-Typical Young Adults under Different White Noise Levels,"* **Scientific Reports,** 12, 1, 2022: 14566.

[315] H. Hao & A.R. Conway, *"The Impact of Auditory Distraction on Reading Comprehension: An Individual Differences Investigation,"* **Memory & Cognition,** 50, 4, 2022: 852-863.

[316] H.W. Brink, M.G. Loomans, M.P. Mobach & H.S. Kort, *"Classrooms' Indoor Environmental Conditions Affecting the Academic Achievement of Students and Teachers in Higher Education: A Systematic Literature Review,"* **Indoor Air,** 31, 2, 2021: 405-425.

[317] L. Leist, C. Breuer, M. Yadav, S. Fremerey, J. Fels, A. Raake, T. Lachmann, S.J. Schlittmeier & M. Klatte, *"Differential Effects of Task-Irrelevant Monaural and Binaural Classroom Scenarios on Children's and Adults' Speech Perception, Listening Comprehension, and Visual–Verbal Short-Term Memory,"* **International Journal of Environmental Research and Public Health,** 19, 23, 2022: 15998.

[318] C. Clark, J. Head, M. Haines, I. van Kamp, E. van Kempen & S.A. Stansfeld, *"A Meta-Analysis of the Association of Aircraft Noise at School on Children's Reading Comprehension and Psychological Health for Use in Health Impact Assessment,"* **Journal of Environmental Psychology,** 76, 2021: 101646.

[319] Q. Liu, Z. Huang, Z. Li, M.R. Pointer, G. Zhang, Z. Liu, H. Gong & Z. Hou, *"A Field Study of the Impact of Indoor Lighting on Visual Perception and Cognitive Performance in Classroom,"* **Applied Sciences,** 10, 21, 2020: 7436.

[320] Y.I.N. Ruozhu, M.Y. Leung & L.I. Yueran, *"A Preliminary Study of the Relationship between Built Environment of Open Space and Cognitive Health of Older People."* **Journal of Contemporary Urban Affairs,** 7, 2, 2023: 144-155.

[321] X. Fu, D. Feng, X. Jiang & T. Wu, *"The Effect of Correlated Color Temperature and Illumination Level of LED Lighting on Visual Comfort during Sustained Attention Activities,"* **Sustainability,** 15, 4, 2023: 3826.

[322] I. Konstantzos, S.A. Sadeghi, M. Kim, J. Xiong & A. Tzempelikos, *"The Effect of Lighting Environment on Task Performance in Buildings: A Review,"* **Energy and Buildings,** 226, 2020: 110394.

[323] N. Castilla, J.L. Higuera-Trujillo & C. Llinares, *"The Effects of Illuminance on Students' Memory. A Neuroarchitecture Study,"* **Building and Environment,** 228, 2023: 109833.

[324] Z. Kong, Q. Liu, X. Li, K. Hou & Q. Xing, *"Indoor Lighting Effects on Subjective Impressions and Mood States: A Critical Review,"* **Building and Environment,** 224, 2022: 109591.

[325] Y.K. Juan & Y. Chen, *"The Influence of Indoor Environmental Factors on Learning: An Experiment Combining Physiological and Psychological Measurements,"* **Building and Environment,** 221, 2022: 109299.

[326] I.L. Niza, M.P. de Souza, I.M. da Luz & E.E. Broday, *"Sick Building Syndrome and Its Impacts on Health, Well-Being and Productivity: A Systematic Literature Review,"* **Indoor and Built Environment,** 33, 2, 2024: 218-236.

[327] P. Dhungana & M. Chalise, *"Prevalence of Sick Building Syndrome Symptoms and Its Associated Factors among Bank Employees in Pokhara Metropolitan, Nepal,"* **Indoor Air,** 30, 2, 2020: 244-250.

[328] A.O. Afolabi, A. Arome & F.T. Akinbo, *"Empirical Study on Sick Building Syndrome from Indoor Pollution in Nigeria,"* **Open Access Macedonian Journal of Medical Sciences,** 8, E, 2020: 395-404.

[329] S. Kalender-Smajlović, A. Kukec & M. Dovjak, *"The Problem of Indoor Environmental Quality at a General Slovenian Hospital and Its Contribution to Sick Building Syndrome,"* **Building and Environment,** 214, 2022: 108908.

[330] I.K. Shim, J. Kim, S.R. Won, E.S. Hwang, Y. Lee, S. Park, J. Ryu & J. Lee, *"Prevalence o Sick Building Syndrome Symptoms and Subjective–Objective Indoor Air Quality of Stores in Underground Shopping Districts of Korea,"* **Building and Environment,** 228, 2023: 109882.

[331] N. Zubir, J. Jalaludin & I. Rasdi, *"Indoor Air Quality and Psychosocial Factors Related To Sick Building Syndrome among Office Workers in New and Old Buildings of a Public University in Klang Valley, Malaysia,"* **Malaysian Journal of Medicine & Health Sciences,** 18, 2022.

[332] M. Sarkhosh, A.A. Najafpoor, H. Alidadi, J. Shamsara, H. Amiri, T. Andrea & F. Kariminejad, *"Indoor Air Quality Associations with Sick Building Syndrome: An Application of Decision Tree Technology,"* **Building and Environment,** 188, 2021: 107446.

[333] J. Hou, Y. Sun, X. Dai, J. Liu, X. Shen, H. Tan, H. Yin, K. Huang, Y. Gao, D. Lai & W. Hong, *"Associations of Indoor Carbon Dioxide Concentrations, Air Temperature, and Humidity with Perceived Air Quality and Sick Building Syndrome Symptoms in Chinese Homes,"* **Indoor Air,** 31, 4, 2021: 1018-1028.

[334] R.M. Ketema, A. Araki, Y. Ait Bamai, T. Saito & R. Kishi, *"Lifestyle Behaviors and Home and School Environment in Association with Sick Building Syndrome among Elementary School Children: A Cross-Sectional Study,"* **Environmental Health and Preventive Medicine,** 25, 2020: 1-11.

[335]F. Quesada-Molina & S. Astudillo-Cordero, *"Indoor Environmental Quality Assessment Model (IEQ) for Houses,"* **Sustainability,** 15, 2, 2023: 1276.

[336] S.N.A.M. Noor & H.H. Ding, *"Indoor Environment Quality (IEQ): Temperature and Indoor Air Quality (IAQ) Factors toward Occupants Satisfaction,"* In IOP Conference Series: **Materials Science and Engineering,** 864, 1, 2020: 012012.

[337] Q. Jin & H. Wallbaum, *"Improving Indoor Environmental Quality (IEQ) for Occupant Health and Well-Being: A Case Study of Swedish Office Building,"* In IOP Conference Series: **Earth and Environmental Science,** 588, 3, 2020: 032072.

[338] S. Quarta, A. Levante, M.T. García-Conesa, F. Lecciso, E. Scoditti, M.A. Carluccio, N. Calabriso, F. Damiano, G. Santarpino, T. Verri & P. Pinto, *"Assessment of Subjective Well-Being in a Cohort of University Students and Staff Members: Association with Physical Activity and Outdoor Leisure Time during the COVID-19 Pandemic,"* **International Journal of Environmental Research and Public Health,** 19, 8, 2022: 4787.

[339] I.R. Samuel & A. Ukpoh, *"Influence of Teachers' Attitude towards Practical Chemistry on Senior Secondary Schools Students' Interest and Achievement in Nasarawa State, Nigeria,"* **International Journal of Innovative Psychology & Social Development,** 9, 3, 2021: 139-149.

[340] N. Sadafi & L. Azhdari, *"Investigating the Impact of Nature in Designing Cultural Environments for Children,"* **International Journal of Engineering and Management Sciences,** 5, 1, 2020: 244-256.

[341] S. Kalender Smajlović, A. Kukec & M. Dovjak, *"Association between Sick Building Syndrome and Indoor Environmental Quality in Slovenian Hospitals: A Cross-Sectional Study,"* **International Journal of Environmental Research and Public Health,** 16, 17, 2019: 3224.

[342] Z. Deng, B. Dong, X. Guo & J. Zhang, *"Impact of Indoor Air Quality and Multi-Domain Factors on Human Productivity and Physiological Responses: A Comprehensive Review,"* **Indoor Air,** 2024, 2024.

# Chapter Three

# Methodology

This chapter covered the procedures and techniques for evaluating IEQ components in hostel rooms. It also examined the impact of IEQ on students' wellbeing in selected university hostels in Oyo state, Nigeria. This methodology focused on key aspects such as the research approach, sampling techniques, data collection methods, and analytical tools employed in the study.

## 3.1 The Study Area

This study was conducted in Oyo State, Nigeria. Oyo State is an inland state in Southwestern Nigeria, with Ibadan serving as its capital. With a projected population of 7,840,864 in 2016, it is the third most populated city in the nation and was once the second most populous city in Africa[1]. Approximately 28,454 square kilometres make up its area, and it is situated in latitude 7°51'9.25"N and longitude 3°55'52.5"E. Old, hard rocks and dome-shaped hills make up the terrain. The hills ascend gradually from 500 metres in the southern section to 1200 metres in the northern section above sea level [2].

Oyo State has an equatorial climate, which is notable for having dry and wet seasons with comparatively high humidity. The wet season runs from April to October, and the dry season is between November and March. The average daily temperature is between 25°C and 35°C during the majority of the year[3]. Its vegetation is characterized by guinea savannah in the north and rain forest in the south. The thick forest in the south gives way to grassland scattered with trees in the north[3].

Additionally, Oyo state is a home to the University of Ibadan, the nation's first premier university, as well as a number of other universities, including Atiba University, Oyo, Abiola Ajimobi Technical University, Ibadan, Ladoke Akintola University, Ogbomoso, Dominican University, Ibadan, Precious Corner Stone University, Ibadan, Lead City

University, Ibadan, Ajayi Crowther University, Oyo, Kola Daisi University, Ibadan and Dominion University, Ibadan, making a total of 10 universities sited in Oyo State.

There are four (4) selected Universities for this study. One of the selected universities, University of Ibadan, as a study area, is situated in urban setting of Ibadan over a land area of 2,550 acres at a latitude $7.4433^0$N and longitude $3.9003^0$E. Abiola Ajimobi Technical University also situated in Ibadan on a 200 hectare of land at latitude $7^0 14'21.923^0$N and longitude $3^0 49'19.596^0$E while Ajayi Crowther University is located in Oyo town on a land area of 37.02 hectares at latitude and longitude of $7.8489^0$N and $3.94809^o$E respectively. Finally, Lead City University is located in urban area of Ibadan on 5 acres of land area at latitude $7.327^o$N and longitude $3.880^o$E [2] (**Appendix I**).

## 3.2 Research Philosophy

The research philosophy refers to the scientific approach that is based on people's beliefs and assumptions about the nature of knowledge. Research philosophy can assist in categorizing the type of evidence required, how to collect it, and how to comprehend it in order to discover an answer to the fundamental problem under research. Reference to research philosophies allows researchers to answer research issues by discovering, adapting, or even constructing research designs that go beyond existing experience and knowledge[4]. Furthermore, the research philosophy is dependent on the researcher's beliefs and assumptions about the knowledge process[5]. Failure to contemplate through philosophical problems can have major consequences on the quality of management research[6]. Understanding philosophical questions is important because it can assist in understanding the research designs, through which data is gathered and analyzed.

Therefore, the research philosophy utilized in this work is Positivism. Positivism is an aspect of epistemology that integrates positivist perspectives within the scope of am investigation, and thus considered as the root paradigm of quantitative method[5]. It therefore integrates quantitative crude data, more like the natural scientific approach as well as affirming that only observable phenomena can lead to credible data[5].

### 3.3 Research Design

The research design incorporated for this study is a Cross-sectional (descriptive and explorative) survey. A research design is essentially a description of the purpose of the inquiry as well as the procedure for gathering data, interpreting it, and recording the findings[7]. Thus, the research design must include an explicit description of the research problem, the techniques and approaches for acquiring information, the population to be investigated, and the methods for processing and analyzing data[8].

#### 3.3.1 Research Strategy

The research strategy used in this study is quantitative. The strategy adopted combines both physical dimensions of the selected hostel rooms' layout and questionnaires, to gain a comprehensive understanding of the hostel rooms' Indoor Environmental Quality (IEQ) components and its impacts on students' wellbeing so as to strengthen the understanding of the research problems As a result, a combination of methods may be more suited to be utilized and therefore, more preferable than one.

#### 3.3.2 Research Approach

The adopted research approach for this study is essentially a deductive approach, focused solely to promptly collect huge amounts of data, typically collected through quantitative data, gotten from the samples and thus analyzed descriptively and inferentially[5]. This deductive approach is usually used in quantitative research where numerical data is collected and analyzed. It is also a Top-down approach which commences with a general theory or hypothesis and then tests it with collected observations or data to make specific conclusion.

### 3.4 Study Population

The context of study population/unit of analysis for this study consisted of three tiers of target of investigation. These are: universities, hostels, and students. The students who reside in hostels make up the study population.

#### 3.4.1 Selection of Universities as the First Tier of Target of Investigation

In this study, the selection of universities as the first tier of unit of analysis/study population was derived using a two-stage sampling technique. This involves a sampling plan in which sampling is carried out in phases, utilizing sampling frames at each stage. The sampling stages for this research are as follows:

##### 3.4.1.1 Stage 1: Stratified Sampling

This entails dividing the population into discrete groups or strata that do not overlap, and then selecting the study sample from the stratum using random sampling. Thus, in this study, all ten (10) universities situated in Oyo State as at the time of the study were stratified into three strata according to their ownership status. These include one (1) Federal, two (2) State, and seven (7) Private owned universities.

**Table 3.1**: Stratification of Universities Situated in Oyo State

| S/N | Name of the Institutions | Location | Ownership Status | | Hostel Purposely Built? |
|---|---|---|---|---|---|
| 1. | University of Ibadan | Ibadan | **Federal Government** | | Yes |
| 2. | Ladoke Akintola University of Technology | Ogbomoso | **State Government** | | Yes |
| 3. | Abiola Ajimobi Technical University, Ibadan | Ibadan | | | Yes |
| 4. | Ajayi Crowther University | Oyo | **Faith based** | **Private** | Yes |
| 5. | Dominican University | Ibadan | | | Nil |
| 6. | Precious Corner Stone University | Ibadan | | | Nil |
| 7. | Lead City University | Ibadan | **Non-Faith based** | | Yes |
| 8. | Kola Daisi University | Ibadan | | | Yes |
| 9. | Atiba University | Oyo | | | Nil |
| 10. | Dominion University | Ibadan | | | Nil |

**Source:** Field Survey, 2024

#### 3.4.1.2 Stage 2: Stratified Random Sampling

This is a type of sampling in which a unit is chosen at a predetermined interval within the population, e.g. the kth unit. As a result, one unit of university was chosen at random from each of the strata of Federal and State-owned institutions, while a unit each was chosen at random from the strata of Faith-based and Non-based Private-owned universities. Thus, the University of Ibadan (Federal Government), Abiola Ajimobi Technical University (State Government), Ajayi Crowther University (Faith-based Private) and Lead City University (Non-Faith-based Private) owned universities students' hostels were selected through stratified random sampling, as the first tier of target of investigation or primary study areas.

### 3.4.2 Selection of the Second and Third Tiers of Target of Investigation

The second and third tiers of target of investigation were identified from the database of students residing in dormitories in each selected institution. This was collected from the Hall Administrators/Wardens of each hostel. This was done to determine the overall number of students to be utilized as the study's population (**Tables 3.2 – 3.6**).

**Table 3.2:** Profile of Hostel Facilities within University, Ibadan

| Name of Hall | Level of Study | Gender | Students Population |
|---|---|---|---|
| Obafemi Awolowo | Undergraduate/Post-graduate | Female | 1,618 |
| Independence | Undergraduate | Male | 847 |
| Queen Idia | Undergraduate | Female | 1300 |
| Nnamdi Azikiwe | Undergraduate | Male | 940 |
| Mellanby | Undergraduate | Male | 509 |
| Sultan Bello | Undergraduate | Male | 566 |
| Queen Elizabeth | Undergraduate | Female | 1600 |
| Kuti | Undergraduate | Male | 557 |
| Tafawa Balewa | Postgraduate | Mixed | 207 |
| Abdulsalam Abubakar | Postgraduate | Mixed | 790 |
| Tedder | Undergraduate | Male | 540 |
| **Total** | | | **9474** |

**Source:** University of Ibadan, Hall Administrator/Warden's Database, 2023

**Table 3.3:** Profile of Hostel Facilities within Abiola Ajimobi Technical University, Ibadan

| Name of Hall | Level of Study | Gender | Students Population |
|---|---|---|---|
| Tech U Hall | Undergraduate | Mixed | 112 |
| El-Salem Hall | Undergraduate | Mixed | 384 |
| **Total** | | | **496** |

**Source:** Abiola Ajimobi Technical University, Ibadan, Hall Administrator/Warden's Database, 2023

**Table 3.4:** Profile of Hostel Facilities within Ajayi Crowther University, Oyo

| Name of Hall | Level of Study | Gender | Students Population |
|---|---|---|---|
| ACU Female Hostel | Undergraduate | Female | 650 |
| Ibadan Hostel | Undergraduate | Male | 350 |
| Lagos Hostel | Undergraduate | Male | 300 |
| Joseph Adetiloye Hostel (JAH) | Undergraduate | Male | 650 |
| Diocese of Lagos West Hostel | Undergraduate | Female | 700 |
| Shepherd-Inn | Undergraduate | Male | 180 |
| Goshen | Undergraduate | Female | 80 |
| ACU Male Hostel | Undergraduate | Male | 70 |
| **Total** | | | **2980** |

**Source:** Ajayi Crowther University, Oyo Hall Administrator/Warden's Database, 2023

**Table 3.5:** Profile of Hostel Facilities within Lead City University, Ibadan

| Name of Hall | Level of Study | Gender | Students Population |
|---|---|---|---|
| Champions Hall | Undergraduate | Male | 106 |
| Wisdom Hall | Undergraduate | Male | 148 |
| Independence Hall | Undergraduate | Male | 202 |
| Victory Hall | Undergraduate | Female | 140 |
| Achievers Hall | Undergraduate | Female | 122 |
| Exodus Hall | Undergraduate | Male | 480 |
| Block L | Undergraduate | Female | 124 |
| Block C | Undergraduate | Female | 118 |
| Block U | Undergraduate | Male | 206 |

| | | | |
|---|---|---|---|
| Block I | Undergraduate | Male | 108 |
| Hibiscus I & II | Undergraduate | Mixed | 128 |
| Maintenance Hall | Undergraduate | Male | 24 |
| Peace I & II | Undergraduate | Male | 150 |
| Proverb Hall | Undergraduate | Female | 96 |
| Revelation I & II | Undergraduate | Female | 128 |
| Camp David I, II, III & IV | Undergraduate | Female | 392 |
| BOT | Undergraduate | Female | 232 |
| Jackson | Undergraduate | Female | 108 |
| **Total** | | | **3,012** |

**Source:** Lead City University, Ibadan, Hall Administrator/Warden's Database, 2023



In this regard, a total study population of 15962 was gotten as detailed thus:

**Table 3.6:** Overall Total Study Population

| Study Area | Population |
|---|---|
| University of Ibadan | 9474 |
| Abiola Ajimobi Technical University | 496 |
| Ajayi Crowther University | 2980 |
| Lead City University | 3012 |
| **Total Study Population** | **15962** |

**Source:** Compilation from Hall Administrators/Warden's Database, 2023

### 3.5 Sample and Sampling Techniques

The process of selecting participants for a research study is known as sampling and a sample size is chosen from the study population [9, 10]. Sampling can be used as a tool when the research population is too broad to study as a whole. As a result of this, a representative sample of the population must be selected for the research work.

### 3.5.1 Sampling Frame

Sampling frame can be described as the complete list of all units or elements from which the sample is selected in all study areas. The primary sampling frame for this research was drawn from selected University of Ibadan (Federal-owned), Abiola Ajimobi Technical University (State-owned), Ajayi Crowther University (Faith based-owned) and Lead City University (Non-Faith based-owned) students' hostels (Tables 3.2, 3.3, 3.4 and 3.5). Hence, the sampling frame covers the overall number of students in all halls of residence in all the study areas. Therefore, the population of students in the University of Ibadan hostels, Abiola Ajimobi Technical University hostels, Ajayi Crowther University hostels and Lead City University hostels are 9,474; 496; 2,980 and 3,012 respectively as at the time of this research, totaling 15962 students (Table 3.6).

### 3.5.2 Sampling Size Determination

However, it is usually not practicable to collect data from every unit of the relevant population of study[11 12]. However, in this study, Yaro Yamane's sample size computation was employed to calculate the overall number of questionnaires distributed in each study area. Therefore, the statistical formula for determining the minimum sample sizes by Yaro Yamane is stated as thus:

**$n = N/1+Ne^2$** where: n = samples size; N= population for the study; e = margin of error ± 5% precision and confidence level ± 95%; 1 = constant (unity).

In this regard, using the above Yaro Yamane formula, the sample size results for each study area were hereby illustrated in the Table 3.7. In order to accommodate non-response, the adjusted value was derived adopting a non-response rate of 7.5%. Therefore, the minimum sample size for each study area is thus derived as:

**Table 3.7:** Primary Sample Sizes for the Study Area

| Study Area | Sampling Population | Sample Size ($n = N/1+Ne^2$) | Allowable 7.5% for Non-Response | Total Sample size |
|---|---|---|---|---|
| University of Ibadan | 9474 | 384 | 26 | 410 |
| Abiola Ajimobi Technical University | 496 | 221 | 19 | 240 |
| Ajayi Crowther University | 2980 | 353 | 27 | 380 |
| Lead City University, Ibadan | 3012 | 353 | 27 | 380 |
| **Total** | **15962** | **1311** | **99** | **1410** |

**Source:** Hall Administrators/Warden's Database, 2023

### 3.5.3 Sampling Technique for Data Collection

The sampling technique to administer the questionnaire for data collection in each study area was random technique. In this regard, the questionnaires were distributed randomly to the students based on Probability Proportion to Size (PPS) as regard to the composition of the students' population in the hostel rooms for better precision. Therefore, the Probability Proportion to Size was used to calculate the size of the samples in each hostel of each respective study area. Therefore, the Probability Proportion to Size (PPS) or the sampling fraction for better precision is calculated as: **n/N*100.** Where: n = samples size of the study area; N= population of the study area.

For instance, the Probability Proportion to Size for University of Ibadan is thereby calculated as thus: **410/9474*100** equals **4.33%**

**Table 3.8:** The Sample Size based on the PPS for University, Ibadan Hostels

| Name of Hall (A) | Students Population (B) | Sample Size with PPS 4.33% (4.33%*B) |
|---|---|---|
| Obafemi Awolowo | 1,618 | 70 |
| Independence | 847 | 37 |
| Queen Idia | 1300 | 56 |
| Nnamdi Azikiwe | 940 | 41 |
| Mellanby | 509 | 22 |
| Sultan Bello | 566 | 25 |
| Queen Elizabeth | 1600 | 69 |
| Kuti | 557 | 24 |
| Tafawa Balewa | 207 | 9 |
| Abdulsalam Abubakar | 790 | 34 |
| Tedder | 540 | 23 |
| **Total Sample Size** | | **410** |

**Source:** Hall Administrators/Warden's Database, 2023



Also, the Probability Proportion to Size for Abiola Ajimobi Technical University, Ibadan Hostel is calculated as thus: **240/496*100** equals **48.4%**

**Table 3.9:** The Sample Size based on the PPS for Abiola Ajimobi Technical University, Ibadan Hostels

| Name of Hall (A) | Students Population (B) | Sample Size with PPS 48.4% (48.4%*B) |
|---|---|---|
| Tech U Hall | 112 | 54 |
| El-Salem Hall | 384 | 186 |
| **Total Sample Size** | | 240 |

**Source:** Hall Administrators/Warden's Database, 2023

The Probability Proportion to Sampling for Ajayi Crowther University, Oyo Hostel is calculated as thus: **380/2980*100** equals **12.75%.**

**Table 3.10:** The Sample Size based on the PPS for Ajayi Crowther University, Ibadan Hostels.

| Name of Hall (A) | Students Population (B) | Sample Size with PPS 12.75% (12.75%*B) |
|---|---|---|
| ACU Female Hostel | 650 | 83 |
| Ibadan Hostel | 350 | 45 |
| Lagos Hostel | 300 | 38 |
| Joseph Adetiloye Hostel (JAH) | 650 | 83 |
| Diocese of Lagos West Hostel | 700 | 89 |
| Shepherd-Inn | 180 | 23 |
| Goshen | 80 | 10 |
| ACU Male Hostel | 70 | 9 |
| **Total Sample Size** | | **380** |

**Source:** Hall Administrators/Warden's Database, 2023



However, the Probability Proportion to Size for Lead City University, Ibadan Hostel is calculated as thus: **380/3012*100** equals **12.62%.**

**Table 3.11:** The Sample Size based on the PPS for Lead City University, Ibadan Hostels

| Name of Hall (A) | Students Population (B) | Sample size with PPS 12.62% (12. 62%*B) |
|---|---|---|
| Champions Hall | 106 | 13 |
| Wisdom Hall | 148 | 19 |
| Independence Hall | 202 | 25 |
| Victory Hall | 140 | 18 |
| Achievers Hall | 122 | 15 |
| Exodus Hall | 480 | 61 |
| Block L | 124 | 16 |
| Block C | 118 | 15 |
| Block U | 206 | 26 |
| Block I | 108 | 14 |
| Hibiscus I & II | 128 | 16 |
| Maintenance Hall | 24 | 3 |

| | | |
|---|---|---|
| Peace I & II | 150 | 19 |
| Proverb Hall | 96 | 12 |
| Revelation I & II | 128 | 16 |
| Calm David I, II, III & IV | 392 | 49 |
| BOT | 232 | 29 |
| Jackson | 108 | 14 |
| **Total Sample Size** | | **380** |

**Source:** Hall Administrators/Warden's Database, 2023



## 3.6 Description of the Research Instrument

### 3.6.1 Instrument for Data Collection and Design

Physical dimension of hostel rooms' layout including the compass orientation of the selected hostel buildings obtained during physical visitation were converted to architectural drawings to collect information on the building geometry, building orientation, numbers of floors, numbers of loadings, headroom, floor area, wall area, window size, window area etc, In conjunction with this, a structured questionnaire was adopted, as the research instrument for collecting primary information for this study. Hence, the questionnaire was divided into three (3) sections. The first segment was intended to collect data on the students' socio-economic information. The second section sought information on students' satisfaction with the IEQ conditions in the hostel rooms, while the third section sought for the levels of students' wellbeing in the hostels rooms. As a result, the questionnaire was designed with closed-ended questions lined with likert rating scales for precise responses, as well as some open-ended questions so that respondents may provide more extensive and in-depth information.

### 3.6.2 Data Collection and Treatment for the Research Objectives

**3.6.2.1 Objective One:** To determine the compass orientation of the hostel buildings and physical dimensions of the selected hostel rooms in the study area.

**Data Characteristics:** Data for this objective are quantitative in nature with Nominal/Ratio as scale of measurement. This data was set to analyze the hostels' geometry, number of floors, number of loading, indoor headroom, floor area, wall area, window (type, size, number, area and orientation) and window position of each selected hostel room.

**Data Source:** The data was derived from physical dimensions of some selected hostel rooms' layout and converted to detailed and measured architectural building drawings.

**Data Analysis:** The results of the data obtained from physical dimensions of the selected hostel rooms' layout were presented in tables, analyzed descriptively and exploratively.

**3.6.2.2 Objective Two:** To examine the adequacies of IEQ components of thermal comfort, IAQ, lighting and acoustic in the study area

**Data Characteristics:** Data for this objective are quantitative and Ratio as scale of measurement. These data were set to analyze the parameters of Window- to-Floor Area (WFR) Ratio, Window-to-Wall Area (WWR) Ratio and Rates of Indoor Ventilation in the hostel rooms.

**Data Source:** The data were extracted/analyzed from the descriptive analysis obtained from the physical dimensions of the selected hostel rooms' layout.

**Data Analysis:** Descriptive analysis was used for the results. This involved the presentation of the result in tables, adopting thermo-spatial analysis calculations.

**3.6.2.3 Objective Three:** To examine the satisfaction of the students with the Indoor Environmental Quality conditions in the hostel rooms of the selected universities

**Data Characteristics:** The data for this objective is quantitative in nature and Ordinal as a scale of measurement. The data was set to evaluate the students' satisfaction on indoor environmental quality conditions of the sampled hostels. Here, the student occupants have to rate their perceived opinions on thermal, indoor air quality, acoustic/noise and visual/lighting variables of IEQ in the sampled hostels.

**Data Source:** The data was obtained from the students of the hostels through the administered questionnaire in likert ratings. A random sampling technique based on Probability Proportion to Size (PPS) was utilized for the distribution of questionnaire to students in all sampled hostels.

**Data Analysis:** Data analysis based on responses from closed ended questionnaires from respondents of the students' hostel were analyzed using descriptive statistics (Percentages, Cross tabulation etc) and inferential analysis (Chi-square, and Post-hoc test).

**3.6.2.4 Objectives Four:** To establish the impact of IEQ conditions on students' wellbeing in the hostel rooms of the selected universities.

**Data Characteristics:** The data for this objective is quantitative in nature with Ordinal and Nominal as scale of measurements. The data is set to extract information on the students' wellbeing levels and establishing the impact of IEQ components on the students' wellbeing.

**Data Source:** The data was got from the respondents through structured questionnaire. Also, a random sampling technique based on Probability Proportion to Size (PPS) was employed to distribute questionnaires in the sample dormitories.

**Data Analysis:** Data was analyzed using descriptive statistics (frequency, cross-tabulation and percentages) and inferential analysis (Regression Analysis).

**Table 3.12:** Data Collection and Treatment for the Research Objectives

| Objectives | Research questions | Source | Variables | Scale of Measurement | Method of Data analysis |
|---|---|---|---|---|---|
| **1. Determine the compass orientation of the hostel buildings and physical dimensions of the hostel rooms in the study area** | What are the compass orientation of the hostel buildings and the physical dimensions of the selected hostel rooms in the study area? | Field Survey (Physical dimensions of hostel rooms' layout) | Hostel geometry, orientation, Number of floors, Number of loading, Headroom, Floor area, Wall area, Type of window, Window positions and Window size, number, area etc | **Nominal and Ratio** | Descriptive analysis in tables and exploratively analyzed |
| **2. Examine the adequacy of IEQ components of thermal comfort, IAQ, lighting and acoustic in the study area** | How adequate are the IEQ components of thermal comfort, IAQ, lighting and acoustic of the selected hostel rooms in the study area? | Field Survey (Extracted from the descriptive analysis got from the physical measurements of the hostel rooms' layout) | Rates of Indoor Ventilation, Window/Floor Area Ratio and Window/Wall Area Ratio | **Ratio** | Descriptive analysiss in tables, adopting thermo-spatial analysis calculations |

| | | | | | |
|---|---|---|---|---|---|
| **3. Investigate the satisfaction of the students with the Indoor Environmental conditions in the hostel rooms of the selected universities** | What are the levels of students' satisfaction with the Indoor Environmental Quality conditions in the hostel rooms? | Field Survey (Questionnaire administration) | Level of thermal comfort sensation, hostel room temperature, air quality, moisture/humidity, acoustic/ noise, visual/lighting | **Ordinal** | Descriptive (Percentages, Cross-tabulation) and Inferential (Chi-square test, Post-hoc test) statistics |
| **4. Investigate the impact of IEQ conditions on Students' wellbeing in the hostel rooms of the selected universities** | What are the impacts of IEQ conditions on the students' wellbeing in the hostel rooms of the selected universities? | Field Survey (Questionnaire administration) | Effect of IEQ on concentration to reading, IEQ effects on productivity, Rating sleep quality level, Rate of motivation to wake up, Effect of IEQ on health status etc | **Ordinal and Nominal** | Descriptive statistics (frequency, cross-tabulation and percentages) and inferential analysis (Regression Analysis). |

***Source:*** Researcher's Review, 2024

**Table 3.13:** Operationalization of Variables for the Study Objectives 1 and 2

| Objectives | Variables | Data Type |
|---|---|---|
| | Building Geometry | Nominal |
| | Number of Rooms | Nominal |
| | Number of loading | Nominal |
| | Headroom | Ratio |
| **Objective 1** | Floor Area | Ratio |
| | Wall Area | Ratio |
| | Number of Windows | Nominal |
| | Size of Windows | Ratio |
| | Area of Windows | Ratio |
| | Building Orientation | Nominal |
| | Type of Windows | Nominal |
| | Window Positions | Nominal |
| **Objective 2** | Rates of Indoor Ventilation | Ratio |
| | Window/Floor Area Ratio | Ratio |
| | Window/Wall Area Ratio | Ratio |

***Source:*** Researcher's Review, 2024

**Table 3.14:** Operationalization of Variables for the Study Objectives 3 and 4

| | | ***Part A:*** *Socio-Economic Information of the Students* | |
|---|---|---|---|
| **SN** | **Concepts & Questions** | **Variables and Measurements** | **Data Type** |
| 1. | Age | **Years:** Below 18 (1); 18-20 (2); 21-23 (3); 24-26(4); 27 and above (5) | Interval |
| 2. | Gender | Male (1); Female (2); Others (3) | Nominal |
| 3. | Body Weight (in Kg) | 40 and below (1); 41-50 (2); 51-60 (3); 61-70 (4); 71-80 (5); 81-90 (6); 91-100 (7); 100 and above (8); | Interval |
| 4. | Number of Occupants | 1-2 students (1); 3-4 students (2); 5-6 students(3); 7-8 students (4); More than 8 students (5). | Interval |
| 5. | Period of occupancy | 1-2 months (1); 3-4 months (2); 5-6 months (3); 7-8 months(4); 9-10 months (5); 11-12 months (6). | Interval |
| 6. | Time spent per day indoor | Morning (1); Afternoon (2); Night (3). | Nominal |
| 7. | Average Duration spent per day indoor. | 3-5 hrs (1); 6–8 hrs (2); 9–11 hrs (3); 12–14 hrs (4); 15-17 hrs (5). | Interval |

| | | | |
|---|---|---|---|
| | ***Part B** (Section I): **Thermal Comfort Assessment*** | | |
| 1. | **Thermal Sensation** (Morning, Afternoon & Night). | **7-point ASHRAE Likert Scale:** Cold (1); cool (2); Slightly cool (3); Neutral (4); Slightly warm (5); Warm (6); Hot (7); | Ordinal |
| 2 | **Thermal Preferences** (Morning, Afternoon & Night). | **5-point ASHRAE Likert Scale:** Much cooler (1); Cooler (2); No change (3); Warmer (4); Much warmer (5). | Ordinal |
| 3 | **Air Movement Sensation** (Morning, Afternoon & Night). | **5-point ASHRAE Likert Scale:** Excellent (1); Very Good (2); Good (3); Fair (4); Poor (5). | Ordinal |
| 4 | **Humidity Sensation** (Morning, Afternoon & Night). | **5-point ASHRAE Likert Scale:** Dry (1); Slightly dry (2); No change (3); Slightly humid (4); Humid (5). | Ordinal |
| 5 | Overall Thermal comfort vote | **5-point ASHRAE Likert Scale:** Very-uncomfortable (1); Slightly-uncomfortable (2); Neutral (3); Slightly-comfortable (4); Very-comfortable (5). | Ordinal |
| | ***Part B** (Section II): **Indoor Air Quality Assessment*** | | |
| 1 | Satisfaction level with the indoor air quality | **5-point Likert Scale:** Very dissatisfied (1); Slightly dissatisfied (2); Neutral (3); Slightly-satisfied (4); Very satisfied (5). | Ordinal |
| 2 | Frequency in window openings | **5-point Likert Scale:** Never (1); Rarely (2); Sometimes (3); Often (4); Always (5). | Ordinal |

| | | | |
|---|---|---|---|
| 3 | Air is smelly | **5-point Likert Scale:** Extremely smelly (1); Moderately smelly (2); Somewhat smelly (3); Slightly smelly (4); Not at all smelly (5). | Ordinal |
| 4 | Air is dusty | **5-point Likert Scale:** Extremely dusty (1); Moderately dusty (2); Somewhat dusty (3); Slightly dusty (4); Not at all dusty (5). | Ordinal |
| 5 | Air is stuffy | Very stuffy (1); Stuffy (2); Neutral (3); Fresh(4); Very fresh (5). | Ordinal |
| | | ***Part B** (Section III): **Acoustic/Noise Assessment*** | |
| 1 | Level of satisfaction with sound/noise | **5-point Likert Scale:** Very dissatisfied (1); Slightly dissatisfied (2); Neutral (3); Slightly-satisfied (4); Very satisfied (5). | Ordinal |
| 2 | Satisfaction level with the quality of speech communication | **5-point Likert Scale:** Very dissatisfied (1); Slightly dissatisfied (2); Neutral (3); Slightly-satisfied (4); Very satisfied (5). | Ordinal |
| 3 | Effects of Noise on concentration to reading. | Yes (1); No (2); Neutral (3). | Nominal |
| | | ***Part B** (Section IV): **Visual/Lighting Assessment*** | |
| 1 | Satisfaction level with overall lighting conditions. | **5-point Likert Scale:** Very dissatisfied (1); Slightly dissatisfied (2); Neutral (3); Slightly-satisfied (4); Very satisfied (5). | Ordinal |
| 2 | Satisfaction level with reflection and glare | **5-point Likert Scale:** Very dissatisfied (1); Slightly dissatisfied (2); Neutral (3); Slightly-satisfied (4); Very satisfied (5). | Ordinal |
| 3 | Frequency in use of natural lighting. | **5-point Likert Scale:** Always (1); Often (2); Sometimes (3); Rarely (4); Never (5). | Ordinal |
| 4 | Frequency in controlling/adjusting lighting. | **5-point Likert Scale:** Always (1); Often (2); Sometimes (3); Rarely (4); Never (5). | Ordinal |

| | | | |
|---|---|---|---|
| 5 | Methods of controlling/ adjusting lighting. | Window blinds/shades (1); Light dimmer (2); Light switch (3); Wall bracket light (4); None (5). | Nominal |
| 6 | Satisfaction with the electrical/artificial lighting. | **5-point Likert Scale:** Very dissatisfied (1); Slightly dissatisfied (2); Neutral (3); Slightly-satisfied (4); Very satisfied (5). | Ordinal |
| 7 | Average period in use of electrical/artificial lighting. | 1-2 hours (1); 3-4 hours (2); 5-6 hours (3); 7-8 hours (4); More than 8 hours (5). | Interval |
| 8 | Level of lighting sufficiency for reading ability | **5-point Likert Scale:** Very insufficient(1); Insufficient (2); Unsure (3); Sufficient (4); Very sufficient (5). | Ordinal |
| 9 | Effect of Lighting on reading ability. | Yes (1); No (2); Neutral (3). | Nominal |
| ***Part C: Level of Students' Wellbeing in the Hostel Rooms.*** | | | |
| 1 | Extent of the effect of IEQ components on concentration to reading | **5-point Likert Scale:** No effect (1); Minor effect (2); Neutral (3); Moderate effect (4); Major effect (5). | Ordinal |
| 2 | IEQ component affecting student's productivity. | **5-point Likert Scale:** Extremely affected (1); Very affected (2); Moderately affected (3); Slightly affected (4); Not at all affected (5). | Ordinal |
| 3 | Rating sleep quality level. | **5-point Likert Scale:** Poor (1); Fair (2); Good (3); Very good (4); Excellent (5). | Ordinal |
| 4 | Rate of motivation to wake up for daily academic activities every morning. | **5-point Likert Scale:** Very low (1); Low (2); Neutral (3); High (4); Very high (5). | Ordinal |

| | | | |
|---|---|---|---|
| 5 | Effect of existing indoor condition on health status. | Yes (1); No (2); Neutral (3). | Nominal |
| 6 | Indication on any health symptom frequently perceived | Headache ( ); Dizziness ( ); Fatique ( ); Dry/Irritated skin ( ); Irritated nose & throat ( ); Irritated eyes ( ); Asthma ( ); Cold hands & feet ( ); Coughing ( ); Concentration difficulty ( ). | Nominal |
| **7** | Rating student's performance in academic activities. | 5-point Likert Scale: Very low (1); Low (2); Average (3); High (4); Very high(5). | Ordinal |

**Sources** [13, 14, 15.]

**3.7 Pilot Test**

To increase the chances of the study's success, a pilot study of the students' dormitories was conducted as part of the design. The pilot survey was conducted to evaluate the validity and reliability of the tool that was utilized for the field evaluation. The instrument's strengths and weaknesses were also examined in the pilot study[16]. Additionally, the pilot survey was conducted to determine whether or not the data collection and analysis approach could be problematic. The feasibility study also assessed the data collection process, which comprised distributing and collecting the administered questionnaire.

In this regard, a pilot survey was conducted in June 2023, in the students' hall of residence of Lead City University using questionnaires designed to elicit information from the respondents in order to test the instrument's strengths and weaknesses and to determine whether the questions in the questionnaire were complicated or not. The responses were reviewed to ensure that the questions in the various sections of the questionnaire were understood clearly. For example, several respondents, particularly non-science students, did not understand the technical terms used in the questions about indoor air quality and thermal comfort. These terms were explained to the affected students and were later attended to, in the questionnaire. Pre-testing the questionnaires assisted in redesigning the affected questions prior to the final administration of the research instruments in the field work, as well as in ensuring internal consistency of the research instrument. Thus, the results of the pilot survey demonstrated that the instrument adopted is suitable and not exceedingly complicated for the respondents within the study area.

### 3.8 Reliability of Research Instrument

The reliability test was conducted to ensure measurement stability, accuracy, and precision. A valid questionnaire should yield similar findings when administered at different times. Reliability assists in detecting biases and flaws in the design of a questionnaire[16]. The reliability test of a measuring device determines the results' internal consistency. The reliability of a test instrument is typically expressed as a coefficient known as "Cronbach's alpha"[17]. To assess overall item correlation within the scale of measurement utilized in this study, a reliability check using Cronbach's coefficient alpha was performed on the survey data. An instrument's reliability is high if the Cronbach alpha coefficient is above or equal to 0.70[16, 18].

Moreso, a scale of measurement can be considered reliable if the coefficient $\alpha$ is $\geq 0.70$. Reliability is deemed reasonable and respectable within the range of $0.70<\alpha\leq 0.80$, and very good when $\alpha > 0.80$[19, 20]. On the other hand, depending on construct fitness, a Cronbach alpha coefficient reliability score of 0.50 to 0.60 could be considered adequate and suitable[21]. When employing an existing or established instrument for a study that has already been tested for reliability, it is critical that the reliability test is repeated because it is being utilized in a different study and with different participants. Similarly, the reliability of an instrument varies from one type of research to the next, as well as from one participant group to the next[22]. The instrument validity test was based on students' subjective survey data gathered during the time frame of measurement from one of the study areas.

Therefore, according to the reliability test for this study instrument (questionnaire) that was carried out in one of the study areas (Lead City University's students' hostels), it was found that the results of the Cronbach's coefficient alpha of the instrument's reliability are $\alpha \geq 0.70$ and $\alpha > 0.80$ for objectives 4 and 5 respectively. Thus, these results signified that the instrument (questionnaire) is reliable, acceptable or very good[19 20]. The result of reliability scales of measurement are as follow:

**Table 3.15:** Reliability Test Result for the Objectives (Ordinal Variables)

| Objectives | Cronbach's Alpha | No of Items |
|---|---|---|
| Objective 1 | - | - |
| Objective 2 | - | - |
| Objective 3 | 0.703 | 18 |
| Objective 4 | 0.818 | 4 |

***Source:*** Researcher's Review, 2024

### 3.9 Data Source

This section explains the commonly used data collection methods as well as their respective data analysis methods. The term methods refer to the tools that are used in collecting and analyzing data. Data may be collected from primary or secondary sources[23, 8]. Primary source is either qualitative techniques involving the use of conversation and in-depth semi-structured/structured interviews or quantitative data involving the use of structured surveys/questionnaire, attitude scaling and field equipment to collect information/data or both[24, 10]. On the other hand, secondary data refers to information, which already exists; for instance, archival records, company documentation, publications, and annual reports.

Therefore, data for this study was collected from both primary and secondary sources. The primary source of data collection was through the quantitative aspect of physical measurement of hostel rooms' layout in conjunction with the structured questionnaires administered to sampled students. Regarding this, random sampling technique based on Probability Proportion to Size (PPS) was employed for the distribution of questionnaire to the student occupants in the selected hostels. However, secondary data was sourced from the existing publications.



### 3.10 Methods of Data Analysis

Data analysis is a process of generating, developing, and verifying data. The process develops with the acquisition of data. The quantitative analysis was adopted during data collection. This was achieved by recording and interpreting analytical insights drawn from the data collection during fieldwork. The data analysis processing involved data editing, coding, statistical adjustment of the data and data analysis & interpretation.

In this study, the obtained data from the physical dimensions of the hostel rooms' layout (hostels' geometry, number of floors, number of loading, indoor headroom, floor area, wall area, window (type, size, number, area and orientation) and window position) for each selected hostel room were analyzed. Also, the use of thermo-spatial analysis calculations to obtain the rate of indoor ventilation, Window/Floor Area Ratio and Window/Wall Area Ratio was further descriptively analyzed. Furthermore, the obtained data from the field via the usage of Likert rating scale questionnaires was quantitatively analyzed, edited, coded, adjusted and fed into a software named Statistical Package for Social Science (SPSS) which was further descriptively and inferentially analyzed.

### 3.11 Ethical Approval

In order to minimize oversight, prevent fabrication and falsification, promote knowledge and the truth, and prevent human rights violations during the research process, ethical considerations must be taken into account when authenticating data gathering. It is critical for establishing confidence with participants in this research because it includes interacting with individuals in hostel rooms while upholding their rights. The participants in this research gave their full approval and their confidentiality was guaranteed to remain secure during the administration of the questionnaires. Since no information would be connected to any participant directly, the strictest standards of confidentiality and anonymity were upheld when presenting the findings. Respondents were given a clear explanation of the study's aim and objectives, alongside the steps involved, to ensure that the information they provided was accurate and free from external influences. Since the data was securely saved to prevent unauthorized access, the opinions of the participants will be honoured.

## Endnotes

1. K. Nenge, *Which is the largest city in Africa: Lagos vs. Ibadan city,* Legit. ng-Nigeria news, https://www.legit.ng/1212538-is-ibadan-largest-city-africa.html (7th March, 2021).

2. R. S. Ganiyu & S. O. Makinde, "*Towards Value Re-Orientation of Primary School Female Teachers on the Role of ICT in Teaching and Learning in Oyo Town, Nigeria*," **Nigerian Online Journal of Educational Sciences and Technology**, 3, 1, 2021: 66-72.

3. O.B. Awosolu, Z. S. Yahaya, M. T. F. Haziqah, I. A. Simon-Oke & C. Fakunle, "*A Cross-Sectional Study of the Prevalence, Density, and Risk Factors Associated with Malaria Transmission in Urban Communities of Ibadan, Southwestern Nigeria,"* **Heliyon,** 7, 1, 2021: 59-75

4. S.P. Taylor, "*A Realist Philosophical Approach for Housing Research: Critical Realism*," **International Journal of Housing and Human Settlement Planning**, 6, 2, 2020: 1-20.

5. D. Ivanov, "*Modeling Supply Chain Resilience. In Introduction to Supply Chain Resilience: Management, Modelling, Technology*," Cham: Springer International Publishing, 2021: 63-92.

6. A. Mostepaniuk, E. Nasr, R.I. Awwad, S. Hamdan & H.Y. Aljuhmani, "*Managing a Relationship between Corporate Social Responsibility and Sustainability: A Systematic Review,"* **Sustainability,** 14, 18, 2022: 11203.

7. C.E. Hacini, Y. Bada & C. Pihet, "*The Mobility of People with Disability: Between Urban Accessibility and Urban Attractiveness. A Case Study from Algiers, Algeria*," **International review for spatial planning and sustainable development***,* 10, 2, 2022: 38-57.

8. H.K. Mohajan, "*Quantitative Research: A Successful Investigation in Natural and Social Sciences*," **Journal of Economic Development, Environment and People**, 9, 4, 2020: 50-79.

9. R.F. Fellows & A.M. Liu, "*Research Methods for Construction",* United Kingdom: John Wiley & Sons, 2021: 88-120.

10. O. Asaju, O. Alagbe & O. Adetona, "*Investigation of Indoor Environmental Quality of Lecture Rooms on Students' Comfort in Selected Polytechnics, Lagos, Nigeria:* In *Towards a Sustainable Construction Industry: The Role of Innovation and Digitalisation",* Proceedings of 12th Construction Industry Development Board (CIDB) Postgraduate Research Conference (Cham: Springer International Publishing, 2023), 54-63.

11. S. Rahi, "*Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues and Instruments Development,"* **International Journal of Economics & Management Sciences**, 6, 2, 2017: 1-5.

12. M.K. Alam, "*A Systematic Qualitative Case Study: Questions, Data Collection, Nvivo Analysis and Saturation, Qualitative Research in Organizations and Management,"* **An International Journal**, 16, 1, 2021: 1-31.

13. A. Bassoud, H. Khelafi, A.M. Mokhtari & A. Bada, *"Evaluation of Summer Thermal Comfort in Arid Desert Areas. Case Study: Old Adobe Building in Adrar (South Of Algeria),"* **Building and Environment,** 205, 2021: 108140.

14. J. Kim, J. Ryu, B. Jeong & R. de Dear, *"Semantic Discrepancies between Korean and English Versions of The ASHRAE Sensation Scale,"* **Building and Environment,** 221, 2022: 109343.

15. T. Mamani, R.F. Herrera, F. Muñoz-La Rivera & E. Atencio, *"Variables that Affect Thermal Comfort and Its Measuring Instruments: A Systematic Review,"* **Sustainability**, 14, 3, 2022: 1773.

16. H. Dzwigol, "*Research Methodology in Management Science: Triangulation,"* **Virtual Economics***,* 5, 1, 2022: 78-93.

17. L. Surucu & A. Maslakçi, "*Validity and Reliability in Quantitative Research, Business & Management Studies,"* **An International Journal**, 8, 3, 2020: 2694-2726.

18. H. Taherdoost, "*Data Collection Methods and Tools for Research: A Step-by-Step Guide to Choose Data Collection Technique for Academic and Business Research Projects*," **International Journal of Academic Research in Management (IJARM),** 10, 1, 2021: 10-38.

19. M.A. Bujang, E.D. Omar, D.H.P. Foo & Y.K. Hon, "*Sample Size Determination for Conducting a Pilot Study to Assess Reliability of a Questionnaire,"* **Restorative Dentistry & Endodontics,** 49, 1, 2024.

20. I. Ahmed & S. Ishtiaq, "*Reliability and Validity: Importance in Medical Research,"* **Methods,** 12, 1, 2021: 2401-2406.

21. Z. Aginako, M.B. Peña-Lang, M.T. Bedialauneta & T. Guraya, "*Analysis of the Validity and Reliability of a Questionnaire to Measure Students' Perception of Inclusion of Sustainability in Engineering Degrees,"* **International Journal of Sustainability in Higher Education**, 22, 6, 2021: 1402-1420.

22. P. Leavy, *"Research Design: Quantitative, Qualitative, Mixed Methods, Arts-based, and Community-based Participatory Research Approaches,"* New York: *Guilford Publications*, 2022, 87-116.

23. I. Etikan & K. Bala, "*Sampling and Sampling Methods,"* **Biometrics & Biostatistics International Journal,** 5, 6, 2017, 1-49.

24. H.K. Mohajan, "*Quantitative Research: A Successful Investigation in Natural and Social Sciences*," **Journal of Economic Development, Environment and People***,* 9, 4, 2020: 50-79.

# Chapter Four

## Results and Discussion of Findings

This chapter presents the results and discussion of data collected and analyszed in the field survey. Physical measurement of selected hostel rooms' layout was carried out and transformed into architectural drawings. Furthermore, between the months of July and November, 2023; a total of 1410 questionnaires were administered to students in hostels of four (4) Universities, stratified and randomly selected from ten (10) Universities in Oyo State, Nigeria. Out of these, 1372 questionnaires were retrieved and analyzed accordingly. This represented an acceptable 97.3% response rate of the 1410 sample size for the survey.

### 4.1 Presentation of Data

**4.1.1 Research Question One:** What are the orientation of the hostel buildings and the physical dimensions of the selected hostel rooms in the study area?

Based on the highest number of occupants in each student's dormitory in respective selected universities' hostels as at the time of this study; the result in Table 4.1 captured the breakdown of compass orientation of the hostel buildings and the physical dimensions of the selected hostel rooms. The selected hostel rooms are Obafemi Awolowo hostel representing University of Ibadan; El-Salem hall representing Abiola Ajimobi Technical University; Exodus hall representing Lead City University while Diocese of Lagos West hostel representing Ajayi Crowther University. The variables measured and considered for each selected hostel room are Building geometry; Building orientation; Number of floors; Number of loading; Headroom; Floor and Wall areas; Window number, size & area, Type of window and Window position to each other.

**Table 4.1:** Physical Measurement of Selected Hostel Rooms' Layout

| Institution | Geometry | No of floors | No of loading on Corrid or | Head room (m) | Floor Area of Typical Room ($m^2$) | Wall Area ($m^2$) | Windows | | | | Type of Window | Window Position to each other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | *No* | *Size* ($m^2$) | *Area* ($m^2$) | *Orientation* | | |
| *University of Ibadan* | U-Shaped | Seven | Single | 3.0 | 11.39 | 9.1 | One | 1.8x1.5 | 2.7 | E-W or N-S | Sliding | Opposite |
| | | | | | | 9.1 | One | 1.2x1.5 | 1.8 | | | |
| *Abiola Ajimobi Technical University* | Enclosed courtyard Shaped | Two | Single | 3.0 | 15.12 | 10.8 | Two | 0.9x1.2 | 1.08 | SE-NW | Sliding | Opposite |
| | | | | | | 10.8 | Two | 0.9x1.2 | 1.08 | | | |
| *Lead City University* | I-Shaped | Three | Double | 3.0 | 21.84 | 11.7 | One | 1.2x1.2 | 1.44 | SE-NW | Sliding | Opposite |
| | | | | | | 11.7 | One | 1.2x1.2 | 1.44 | | | |
| *Ajayi Crowther University* | U-Shaped | Four | Single | 3.45 | 40.8 | 20.7 | Two | 0.9x1.8 | 1.62 | N-S or E-W | Sliding | Opposite |
| | | | | | | 20.7 | One | 1.2x1.8 | 2.16 | | | |

**Source:** Researcher's Field Survey, 2024 (Extracted from Appendices III-VI)

#### 4.1.1.1 Building Geometry

The Obafemi Awolowo hostel (University of Ibadan) and Diocese of Lagos West hostel (Ajayi Crowther University) buildings were designed in a U-shaped or partially enclosed building form while, Exodus hall (Lead City University) and El-Salem hall (Abiola Ajimobi Technical University, Ibadan) were designed in I-shaped (Linear) and fully-enclosed courtyard shaped respectively. Building geometry is a critical aspect and factor in achieving satisfactory and comfortable IEQ conditions in the indoor.

A related research identified that, U-shaped buildings provide and promote a more satisfactorily natural light and ventilation than fully-enclosed courtyard and I-shaped building geometries. Moreso, I-shaped building geometry increases heat gain and heat loss due to the larger surface area-to-volume ratio and it can be more prone to noise pollution due to larger surface area exposed to external noise sources[1]. Furthermore, building geometry can significantly influence IEQ conditions, hence, promoting occupants' satisfaction, health, productivity and wellbeing [2].

Therefore, Obafemi Awolowo hostel (University of Ibadan) and Diocese of Lagos West hostel (Ajayi Crowther University) buildings with a U-shaped geometry were satisfactorily designed better than I-shaped and fully-enclosed courtyard geometric buildings of Exodus hall (Lead City University) and El-Salem hall (Abiola Ajimobi Technical University) respectively.

This implies that U-shaped geometrical designs provide satisfactory, comfortable and quality indoor ambience conditions, with enhanced occupants' productivity and wellbeing than I-shaped building designs.

#### 4.1.1.2 Number of Floors

The Obafemi Awolowo hostel (University of Ibadan) is a 7-floor building; El-Salem hall (Abiola Ajimobi Technical University, Ibadan) is a 2-floor building while Exodus hall (Lead City University) and Diocese of Lagos West hostel (Ajayi Crowther University) are 3-floor and 4-floor buildings respectively.

A research confirmed that, taller building reduces natural light availability on lower floors, increases noise levels due to additional sources and reverberation, and heat stratification occurrence in taller building leading to temperature differences between floors.[3, 4]. Furthermore, in taller building, pollutant distribution and concentration can vary by floors due to ventilation rates and source locations, and accumulation of moisture varies by floors due to differences in occupancy, ventilation and temperature [5].

However, hostel rooms of Abiola Ajimobi Technical University with least number of floors provide a better and more satisfaction in the indoor than others with the least satisfaction from the University of Ibadan. The implies that, adequate natural lighting is provided in a low-rise building with reduced noise level, indoor air pollutant and less accumulation of moisture in the indoor thus promoting occupants' satisfaction and wellbeing.

#### 4.1.1.3 Number of Loading

The Obafemi Awolowo hostel (University of Ibadan); Diocese of Lagos West hostel (Ajayi Crowther University) and El-Salem hall (Abiola Ajimobi Technical University) were single banked buildings while Exodus hall (Lead City University, Ibadan) was double banked.

Single banked buildings enhance and improve natural ventilation & lighting, improved air quality and reduced moisture accumulation due to improved air circulation. It further provides better thermal condition of the indoor due to reduced temperature fluctuation and improved air circulation[6].

Therefore, University of Ibadan; Ajayi Crowther University and Abiola Ajimobi Technical University hostels were satisfactorily designed in terms of number of loading than Lead City University hostel with double-banked. The implication is that, single banked building permits openings for cross ventilation in the building, thus supports higher satisfaction, wellbeing and  improving the indoor environmental conditions in the hostels

#### 4.1.1.4 Headroom

Breakdown of the result revealed that, all hostel rooms across the selected universities exhibited a minimum standard of 3-metre headroom.

In a previous research conducted, it was revealed that, increased or taller headroom permits for better air circulation, reducing airborne pollutants, accommodates larger windows for increasing natural light & ventilation. It also assists in reducing noise levels and enhanced visual & thermal comforts with promoting productivity and wellbeing in the indoors[7].

Therefore, all hostel rooms across the institutions under study exhibit a minimum ceiling height of 3 metres and adequate headrooms were provided in all hostels. This implies that, adequate and satisfactorily designed headroom improves the indoor air quality, enhances visual & thermal comforts, natural lighting and ventilation with better control of humidity resulting into better productivity and wellbeing.

#### 4.1.1.5 Window Number and Position

The breakdown of the result in Table 4.1 showed that Obafemi Awolowo hostel (University of Ibadan) and Exodus hall (Lead City University) comprised of two window openings, each opening located in opposite walls. El-Salem hall (Abiola Ajimobi

Technical University, Ibadan) consists of four window openings with two opening each, located in opposite walls while, Diocese of Lagos West hostel (Ajayi Crowther University) also comprised of three window openings with two and one opening located in opposite walls respectively.

However, finding of similar study confirmed that, the window openings in opposite walls in a space impact IEQ conditions through enhancement of natural ventilation and daylighting, and controlling humidity level. These also resulted into enhanced temperature, improved visual comfort in the building indoor, thus influencing occupants' productivity and wellbeing [8].

Therefore, window openings in all the selected universities under study were adequately and satisfactorily located in opposite walls. This implies that, window openings located in opposite walls allow cross-ventilation, permitting adequate natural lighting and ventilation in the indoors. Hence, comfort, satisfaction, productivity and wellbeing are enhanced

**4.1.1.6 Window Type**

The result from Table 4.1 showed that, all hostels in the selected Universities under study were finished with sliding windows. According to the related research work, sliding windows provide adequate and effective amount of natural lighting into the indoors, essentially for the occupants' mood, productivity and wellbeing[11]. However, sliding window reduces the rates of indoor ventilation thus leading to poor quality of indoor air and thermal discomfort[12].

Therefore, based on the findings, all hostel rooms under study are experiencing inadequate and ineffective ventilation rates in the indoors, essentially influencing thermal discomfort and lessen occupants' productivity and overall wellbeing. Though, all hostel rooms are experiencing maximum amount of natural lighting in the spaces,

**4.1.1.7 Building Orientation**

From Table 4.1; the result of the physical measurement of the hostel rooms' layout showed that, the building of the selected hostels from the University of Ibadan (Obafemi Awolowo hostel) was orientated along N-S or E-W with the window openings facing E-W or N-S direction; El-Salem hall (Abiola Ajimobi Technical University, Ibadan) building was orientated along NE-SW with the window opening facing SE-NW direction. Furthermore, Exodus hall (Lead City University) has its building orientation in NE-SW direction with the openings facing SE-NW while the building orientation of Diocese of Lagos West hostel (Ajayi Crowther University) was in N-S or E-W, having its openings facing E-W or N-S direction.

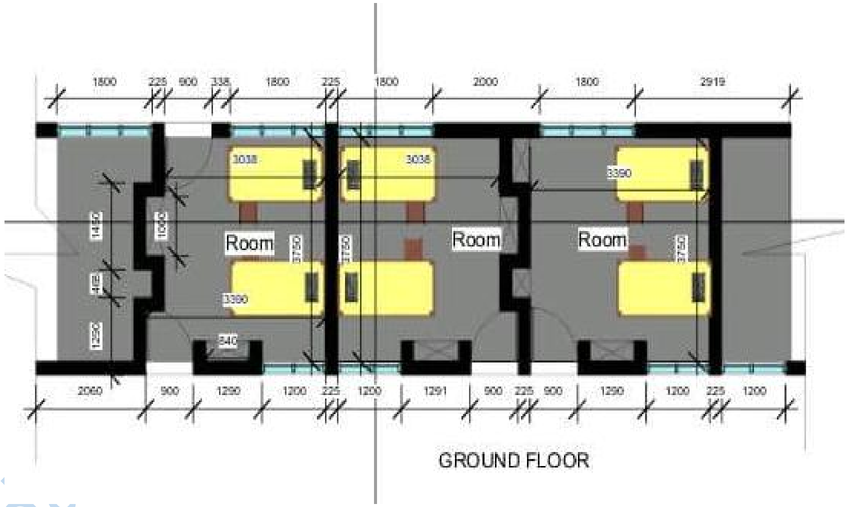
It was found from the similar research that, the window openings facing SE-NW and N-S directions receive gentle, indirect natural light thus, reducing the need for artificial lighting. It also facilitates natural ventilation, improving air quality and reducing the risk of moisture accumulation. SE-NW and N-S window openings orientation can further regulate indoor temperature, thereby reducing heat gains and heat loss in the indoor[9]. However, the window openings facing the E-W direction will be experiencing unsatisfactory condition as E-W direction window opening receives direct sunlight thus leading to heat gain and temperature fluctuation. This E-W direction of openings can also cause glare especially in areas with high reflectance surface[10].

Based on the above similar findings, among all the institutions under study, hostels in Lead City and Abiola Ajimobi Technical Universities, with window opening orientated in SE-NW direction were better and satisfactorily oriented than University of Ibadan and

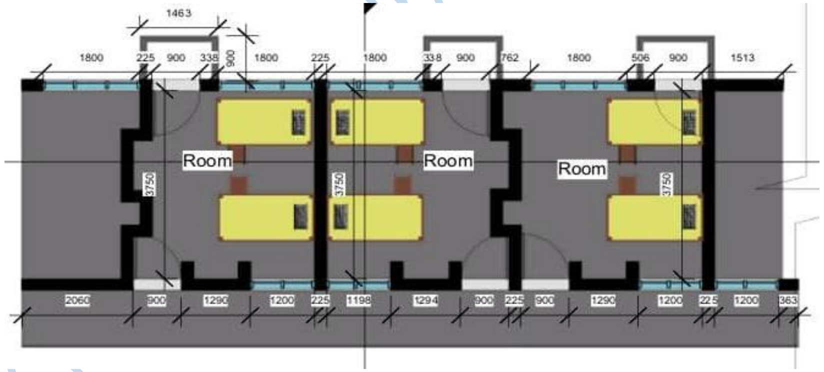
Ajayi Crowther University. The implication of better building orientation permits satisfactory facilitation of natural ventilation, improved indoor air quality and reduced heat gains and heat loss in the indoors.

Summarily, this research question is aligned with Sustainable Development Goals (SDGs) 3, 4, 7, 9 and 11 to create sustainable, healthy and efficient indoor environment for the students[11].

Compass Orientation of Obafemi Awolowo Hostel Rooms




Ground Floor Plan of Obafemi Awolowo Hostel Rooms (Scale: NTS)




1st-6th Floor Plan of Obafemi Awolowo Hostel Rooms (Scale: Not to Scale)

**Figure 4.1a:** Compass Orientation and Floor Plans of Obafemi Awolowo Hostel Rooms, University of Ibadan

**Sources:** Researcher's Fieldwork, 2024

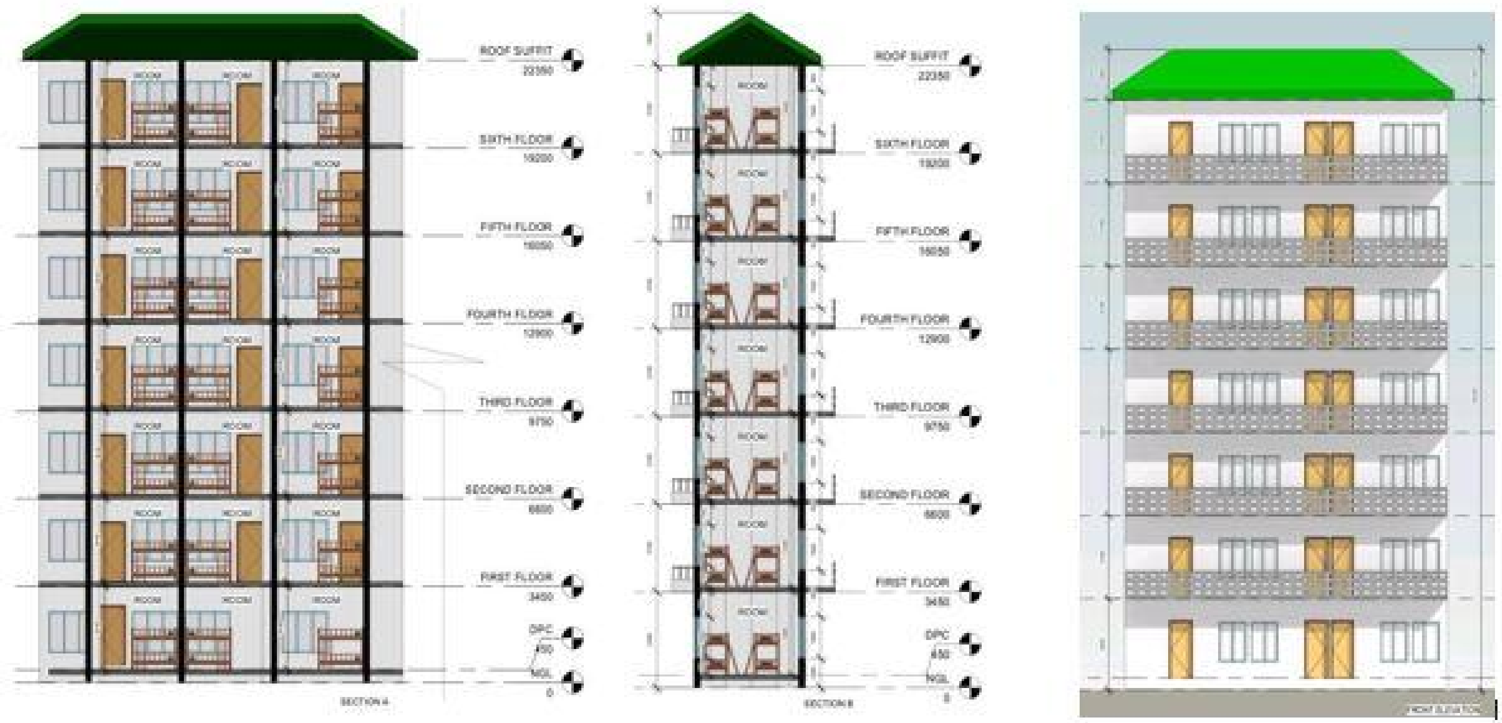



**Figure 4.1b:** Sectional Views of Obafemi Awolowo Hostel Rooms, University of Ibadan (Scale: Not to Scale)

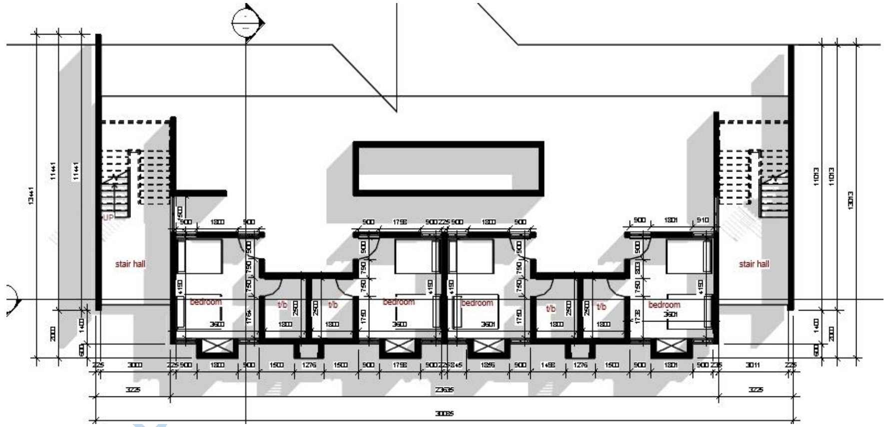
**Sources:** Researcher's Fieldwork, 2024

North or Front View of Obafemi Awolowo Hostel Rooms, University Ibadan

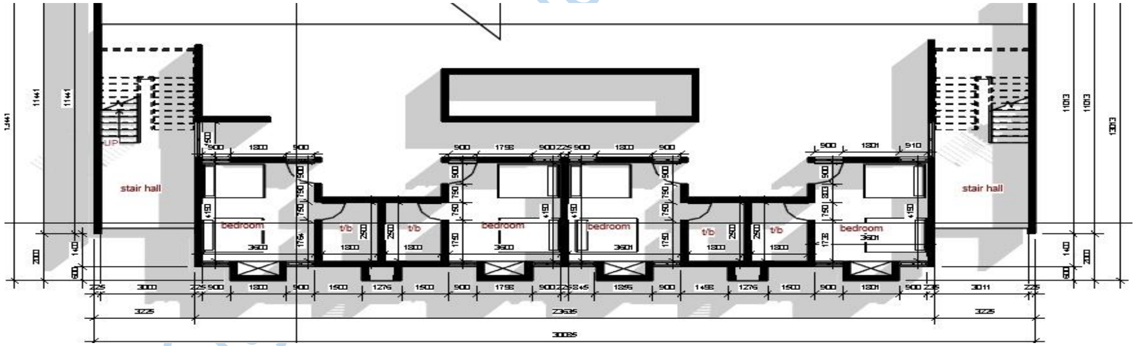
South or Back View of Obafemi Awolowo Hostel Rooms, University of Ibadan

**Plate 4.1:** Elevational Views of Obafemi Awolowo Hostel Rooms, University of Ibadan
**Sources:** Researcher's Fieldwork, 2024


Compass Orientation of El-Salem Hall, Abiola Ajimobi Technical Technical University, University, Ibadan (Scale: NTS)




Ground Floor Plan of El-Salem Hall, Abiola Ajimobi Ibadan (Scale: NTS)




First Floor Plan of of El-Salem Hall, Abiola Ajimobi Technical University, Ibadan (Scale: NTS)

**Figure 4.2a:** Compass Orientation and Floor Plans of El-Salem Hall, Abiola Ajimobi Technical University, Ibadan (Scale: Not to Scale)

**Sources:** Researcher's Fieldwork, 2024


**Figure 4.2b:** Sectional Views of El-Salem Hall, Abiola Ajimobi Technical University, Ibadan (Scale: Not to Scale)

**Sources:** Researcher's Fieldwork, 2024

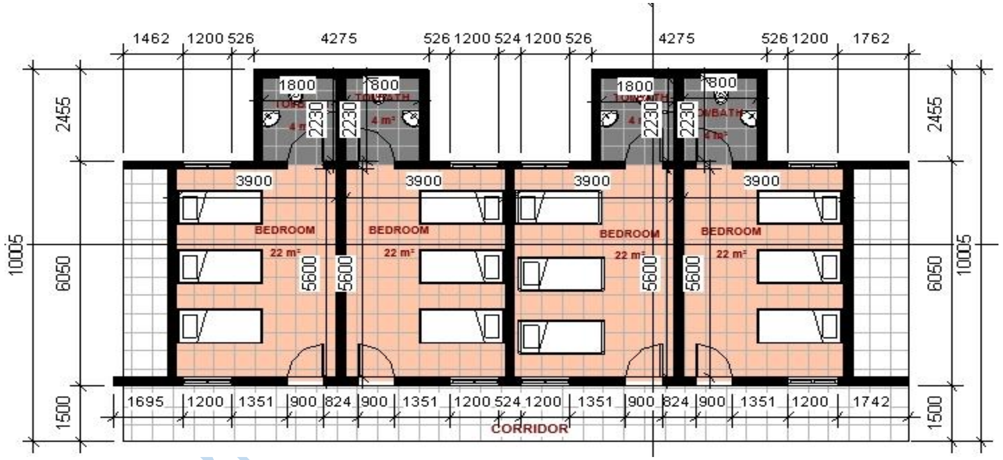
North-West View of El-Salem Hall, Abiola Ajimobi Technical University, University, Ibadan.

South-East View of El-Salem Hall, Abiola Ajimobi Technical Ibadan

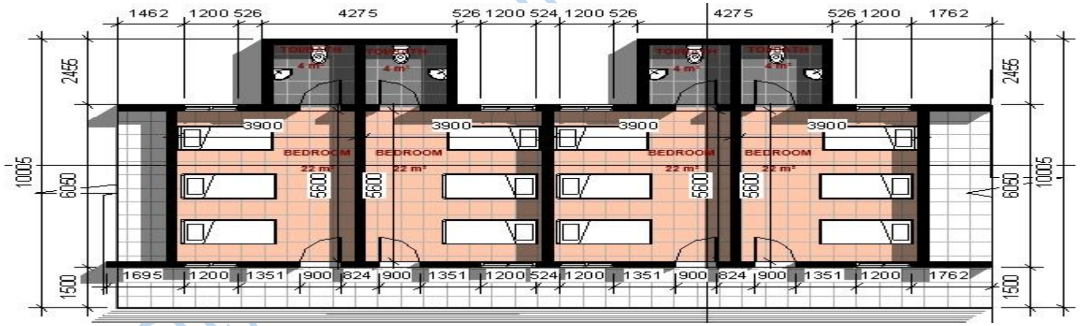
**Plate 4.2:** Elevational Views of El-Salem Hall, Abiola Ajimobi Technical University, Ibadan

**Sources:** Researcher's Fieldwork, 2024

Compass Orientation of Exodus Hostels, Lead City University, Ibadan (Scale: NTS)




Ground Floor Plan of Exodus Hostels, Lead City University, Ibadan (Scale: NTS)




First and Second Floor Plans of Exodus Hostels, Lead City University, Ibadan (Scale: Not to Scale)

**Figure 4.3a:** Compass Orientation and Floor Plans of Exodus Hostels, Lead City University, Ibadan

**Sources:** Researcher's Fieldwork, 2024


**Figure 4.3b:** Sectional Views of Exodus Hostels, Lead City University, Ibadan (Scale: Not to Scale)

**Sources:** Researcher's Fieldwork, 2024



South-West and South East Views of Exodus Hostels, Lead City University, Ibadan

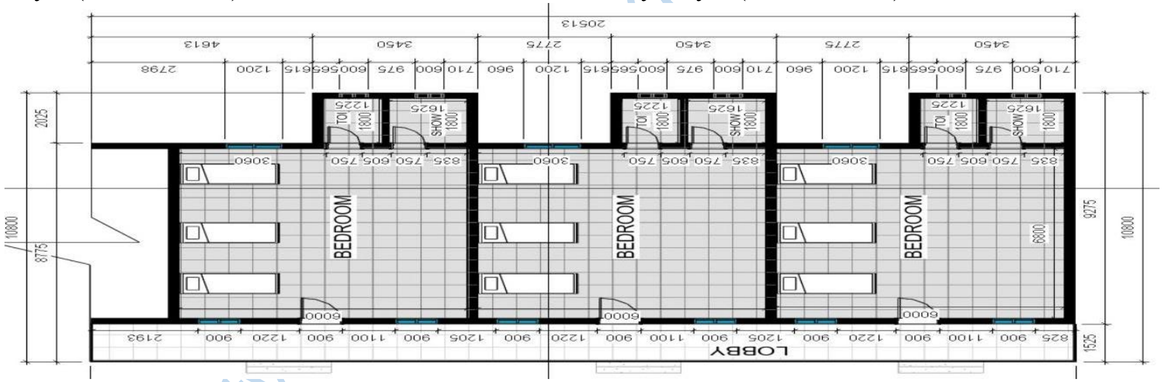
South East Views of Exodus Hostels, Lead City University, Ibadan

**Plate 4.3:** Elevational Views of Exodus Hostels, Lead City University, Ibadan

**Sources:** Researcher's Fieldwork, 2024

Compass Orientation of Diocese of Lagos West Hostel Rooms, Ajayi Crowther University, Oyo (Scale: NTS)

Ground Floor Plan of Diocese of Lagos West Hostel Rooms, Ajayi Crowther University, Oyo (Scale: NTS)




1st – 3rd Floor Plans of Diocese of Lagos West Hostel Rooms, Ajayi Crowther (Scale: Not to Scale)

**Figure 4.4a:** Compass Orientation and Floor Plans of Diocese of Lagos West Hostel Rooms, Ajayi Crowther University, Oyo

**Sources:** Researcher's Fieldwork, 2024

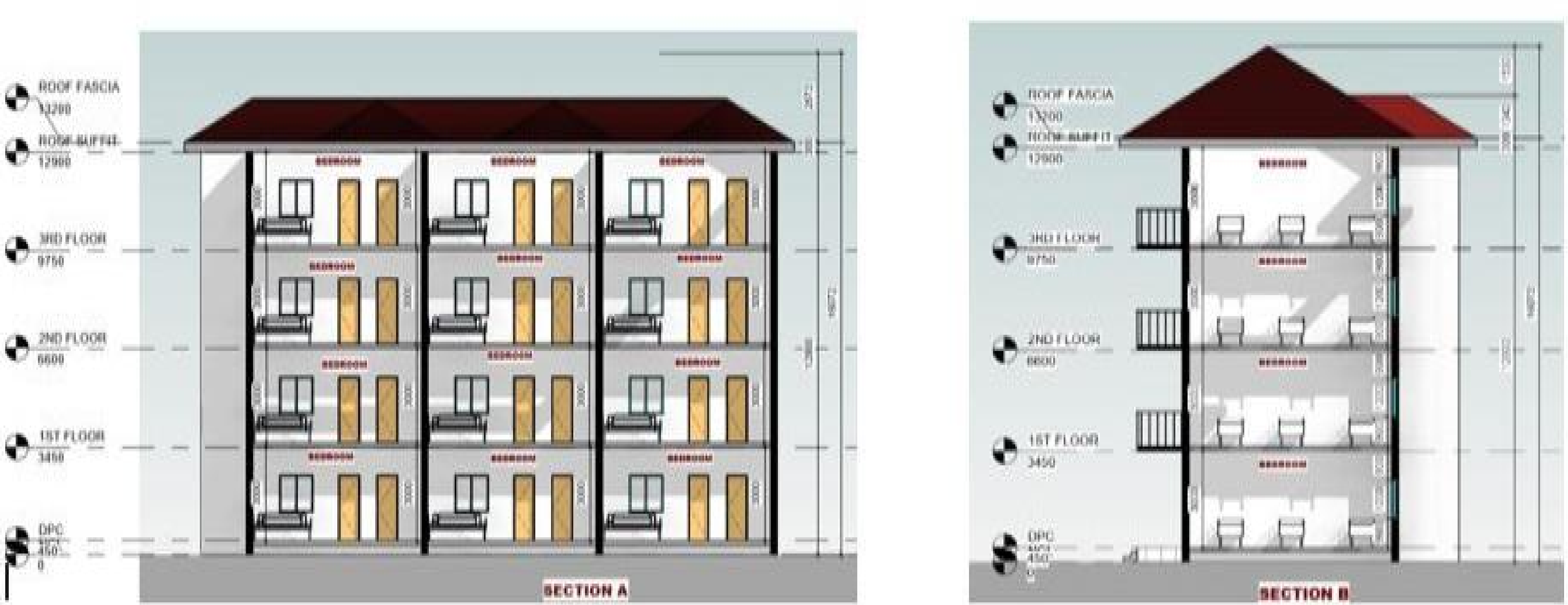



**Figure 4.4b:** Sectional Views of Diocese of Lagos West Hostel Rooms, Ajayi Crowther University, Oyo (Scale: Not to Scale)

**Sources:** Researcher's Fieldwork, 2024


West View of Diocese of Lagos West Hostel Rooms, Ajayi Crowther University, Oyo

East View of Diocese of Lagos West Hostel Rooms, Ajayi Crowther University, Oyo

**Plate 4.4:** Elevational Views of Diocese of Lagos West Hostel Rooms, Ajayi Crowther University, Oyo

**Sources:** Researcher's Fieldwork, 2024

**4.1.2 Research Question Two:** How adequate are the IEQ components of thermal comfort, IAQ, lighting and acoustic using the parameters of Window-to-floor area ratio, Window-to-wall area ratio and Indoor ventilation rates in the study area?

**Table 4.2:** Calculated Percentages of Window-to-Floor Area and Window-to-Wall Area Ratios in the Hostel Rooms.

| **Parameters** | ***University of Ibadan*** | ***Abiola Ajimobi Technical University*** | ***Lead City University*** | ***Ajayi Crowther University*** |
|---|---|---|---|---|
| *Total window area* | 4.5 | 4.32 | 2.88 | 5.4 |
| *Total Floor area* | 11.39 | 15.12 | 21.84 | 40.8 |
| ***Percentage Window /Floor area Ratio (WFR %)*** | **39.51** | **28.57** | **13.19** | **13.24** |
| *Total Window Area* | 4.5 | 4.32 | 2.88 | 5.4 |
| *Total Wall area ($m^2$)* | 18.2 | 21.6 | 23.4 | 41.4 |
| ***Percentage Window/wall area ratio (WWR %)*** | **24.73** | **20.00** | **12.31** | **13.04** |

**Source:** Researcher's Field Survey, 2024

From the result of Physical measurement of hostel rooms layout recorded in Table 4.1; the total Window area, total Floor area and total Wall area for each selected hostel of the institutions under study were extracted into Table 4.2 and used to calculate percentage Window-to-Floor area Ratio (%WFR) and percentage Window-to-Wall area Ratio (%WWR), both calculations to be used to determine the adequacies of thermal comfort, IAQ, lighting and acoustic in the building spaces/indoors.

In this regard, the total window area ($m^2$) for University of Ibadan, Abiola Ajimobi Technical University, Lead City University and Ajayi Crowther University hostels are 4.5;

4.32; 2.88 and 5.4 respectively while the total Floor area ($m^2$) are 11.39; 15.12; 22.84 and 40.8 for each respective institution. In the same regard, the total wall area ($m^2$) for each respective University of Ibadan, Abiola Ajimobi Technical University, Lead City University and Ajayi Crowther University hostel are 18.2; 21.6; 23.4 and 41.4 accordingly.

Nonetheless; **Window-to-Floor Area Ratio (WFR)** is calculated by dividing the total Window area by the total Floor area of a building or space. This is illustrated as: **WFR** = Total Window Area/Total Floor Area while the **Window-to-Wall Area Ratio (WWR)** is calculated by dividing the total Window area by the total Wall area of a building or space. This is illustrated as: **WWR** = Total Window Area /Total Wall Area.

Therefore, the result from Table 4.2 indicated that, the values assessed for percentage Window/Floor area ratios are 39.51%; 28.57%; 13.19% and 13.24% as against University of Ibadan, Abiola Ajimobi Technical University, Lead City University and Ajayi Crowther University respectively while the respective values of 24.73%; 20%; 12.31% and 13.04% were assessed as the percentage Window/Wall area ratios for University of Ibadan, Abiola Ajimobi Technical University, Lead City University and Ajayi Crowther University as well.

Related to percentage Window/Floor area ratio obtained from the result, only hostel rooms of University of Ibadan and Abiola Ajimobi Technical University attained the specified/recommended standard of 20-30% Window/Floor area ratio while others are not. This means that, only University of Ibadan and Abiola Ajimobi Technical University hostel rooms having met 20-30% prescribed Window/Floor area ratio. Furthermore, based on the percentage Window/Wall area ratio, none of the hostel rooms of the selected universities under study attained the specified/recommended standard of 30-50% for window/wall area ratio to achieve satisfactory indoor conditions.

The implication therefore is that, satisfactorily provided Window/Floor and Window/wall area ratios enhance adequate natural lighting and ventilation in the hostel rooms. These promote occupants' thermal and lighting satisfactions; enhance quality indoor air and increase occupants' productivity and wellbeing in the hostels.

The finding on the Window/Floor area ratio is therefore, in compliance with the result of the previous study that the recommended value of openings should be within 20-30% of the space floor area in order to provide a satisfactory and comfortable indoors thus, enhancing occupants' productivity and wellbeing[13]. On the converse, the result of Window/Wall area ratio is not in conformity with the earlier research that, the recommended openings should be within 30-50% of the exposed wall area[13].

**Table 4.3:** Calculated Indoor Ventilation Rates in the Hostel Rooms

| **Typology** | ***University of Ibadan*** | ***Abiola Ajimobi Technical University*** | ***Lead City University*** | ***Ajayi Crowther University*** |
|---|---|---|---|---|
| *Reference Window Area ($m^2$)* | 2.7<br>1.8 | 2.16<br>2.16 | 1.44<br>1.44 | 3.24<br>2.16 |
| *Reference Wall Area ($m^2$)* | 9.1<br>9.1 | 10.8<br>10.8 | 11.7<br>11.7 | 20.7<br>20.7 |
| *Reference Window/wall ratio* | 0.2967<br>0.1978 | 0.2<br>0.2 | 0.1231<br>0.1231 | 0.1565<br>0.1043 |
| *Outdoor wind speed $V_o$ (m/s)* | 1.54 | 2.59 | 2.59 | 2.57 |
| *Indoor Ventilation Rates $V_1$ (m/s)* | 0.4712<br>0.3687 | 0.6248<br>0.6248 | 0.439<br>0.439 | 0.5224<br>0.3817 |
| ***Average Indoor Ventilation Rate $V_1$ (m/s)*** | **0.42** | **0.6248** | **0.439** | **0.4521** |

**Source:** Researcher's Field Survey, 2024



Relatedly, using thermo-spatial calculation, $V_1 = 0.45\ (1 - e^{-3.84x})\ V_0$; where: $V_1$ = Indoor wind velocity; $V_0$ = Average outdoor wind velocity; x = window/wall area ratio; e means Euler's number/exponential (constant) = 2.718; the result in Table 4.3 revealed the calculated indoor ventilation rates in each of the selected hostels under study. Therefore, the indoor ventilation rate of the hostel spaces was deduced from the thermo-spatial calculation of the climatic data of outdoor wind speed of the Universities' locations and the window/wall area ratio of each reference window. In this regard, the average outdoor wind speed for the University of Ibadan, Abiola Ajimobi Technical University, Lead City University and Ajayi Crowther University were obtained from the climate data as 1.54m/s; 2.59m/s; 2.59m/s and 2.57m/s respectively. As a result from Table 4.3, the Indoor ventilation rate for University of Ibadan, Abiola Ajimobi Technical University, Lead City University and Ajayi Crowther University were deduced from the averages of Indoor ventilation rate corresponding to the references of window and wall areas in each institution as 0.42m/s, 0.6248m/s, 0.439m/s and 0.4521m/s respectively.

In this regard, the result of the indoor ventilation rate of all hostel rooms obtained ranged from 0.42m/s to 0.6248m/s across all the institutions under study. Therefore, these values were assessed as adequate in agreement with earlier study conducted that the standard for the indoor wind speed should be within 0.15 m/sand 1.5 m/s for acceptable satisfactory, comfort and wellbeing indoor conditions in the warm-humid climate[14].

Summarily, it is therefore affirmed that the hostel rooms in most of the Universities under study do not appreciably enjoy adequate, satisfactory and comfortable indoor environmental quality (IEQ) components of thermal comfort, indoor air quality, natural lighting and acoustic in the indoors. Though, the ventilation rate was assessed to be adequate and acceptable in all the hostel rooms. The implication noted that, when IEQ conditions are not appreciably adequate and satisfactory in the indoors, health issues like respiratory problems, allergies, infections and diseases envisaged in the indoors leading to stress, sleep inefficiency, discomfort, reduced productivity and wellbeing,

Therefore, the outcome of the result is in contradiction to the earlier research stated that, the IEQ conditions of the indoor spaces are considered acceptable, comfortable and satisfactory, if and only the indoor conditions of the ambience is appreciably adequate in terms of comforts of Indoor Air Quality (IAQ); thermal, lighting and ventilation for the purpose of occupants' satisfaction and overall wellbeing in the indoors[15, 16].

In conclusion, the Sustainable Development Goals (SDGs) 3, 4, 9 and 11 is related to the adequacies of IEQ components of thermal comfort, IAQ, lighting and acoustic adopting the parameters of Window-Floor Area ratio, Window-Wall Area ratio and indoor ventilation rates[11].

**4.1.3 Research Question Three:** What are the levels of students' satisfaction with the Indoor Environmental conditions in the hostel rooms in the study area?

**4.1.3.1 Socio-economic Characteristics of the Students in the selected hostel rooms**

The major thrust of this sub-section is to identify the socio-economic characteristics of the students across the four selected higher institutions of the study area. This is to identify and understand on how these characteristics may affect the levels of students' perception/responses to IEQ satisfactions in the hostel rooms



The results in Table 4.4 indicated that 47.2% of the respondents are within the age range of 18-20; 33.5% within the age range 21-23; 7.9% within the age range 24-26; 5.8% below 18 years; and 5.6% above 27 years. Further breakdown of results based on different institutions revealed that Abiola Ajimobi Technical and Lead City Universities accounted for 4.9% out of 5.8% of respondents below 18 years. Meaning that majority of respondents below 18 years in the sample area are from Abiola Ajimobi Technical and Lead City Universities. For respondents above 27 years, University of Ibadan and Lead City University accounted for 5.5% out of the total percentage (5.6%). Only one person from Ajayi Crowther University is above 27 years of age.

More than half (62.5%) of the respondents are male, while 36.9% are female and 0.6% remains anonymous (prefer not to disclose their gender). Ajayi Crowther University accounts for about 23.6% of male respondents in the sample, while Lead City University accounts for 14.7% of female respondents. In terms of level of study, results in Table 4.4 indicated that 40.1% of the respondents are in their third year (300 level); 22.9% in fourth year (400 level); 22.8% in second year (200 level); 9.3% in fifth year (500 level), and 4.9% post-graduate studies. Out of 40.1% of respondents in their third year, 12.6% and 11.2% respectively are from Ajayi Crowther University and University of Ibadan. Again, University of Ibadan accounts for about 3.6% of the total percentage of respondents (4.9%) pursing post-graduate studies across the four institutions. Furthermore, about 27.3% of respondents weighed between 61-70kg; 27.1% between 51-60kg; 20.1% between 71-80kg; 16.2% between 41-50kg; 4.6% between 81-90kg and 1.9% between 91-100kg.

**Table 4.4:** Socio-economic Attributes of the Resident Students in Hostel Rooms

| Variable | Institution | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age** | **University of Ibadan** | | **AA Technical University** | | **Lead City University** | | **Ajayi Crowther University** | | **Total** | |
| | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** |
| Below 18 | 11 | 0.8 | 29 | 2.1 | 38 | 2.8 | 0 | 0.0 | 79 | 5.8 |
| 18-20 | 143 | 10.4 | 135 | 9.8 | 152 | 11.1 | 218 | 15.9 | 648 | 47.2 |
| 21-23 | 162 | 11.8 | 61 | 4.4 | 100 | 7.3 | 136 | 9.9 | 459 | 33.5 |
| 24-26 | 60 | 4.4 | 1 | 0.1 | 47 | 3.4 | 1 | 0.1 | 109 | 7.9 |
| 27 and above | 34 | 2.5 | 0 | 0.0 | 42 | 3.1 | 1 | 0.1 | 77 | 5.6 |
| **Total** | **410** | **29.9%** | **226** | **16.5%** | **380** | **27.7%** | **356** | **25.9%** | **1372** | **100%** |
| **Gender** | | | | | | | | | | |
| Male | 226 | 16.5 | 133 | 9.7 | 175 | 12.8 | 324 | 23.6 | 858 | 62.5 |
| Female | 180 | 13.1 | 93 | 6.8 | 201 | 14.7 | 32 | 2.3 | 506 | 36.9 |
| Prefer not to say | 4 | 0.3 | 0 | 0.0 | 4 | 0.3 | 0 | 0.0 | 8 | 0.6 |
| **Total** | **410** | **29.9%** | **226** | **16.5%** | **380** | **27.7%** | **356** | **25.9%** | **1372** | **100%** |
| **Level of study** | | | | | | | | | | |
| 200 | 109 | 7.9 | 75 | 5.5 | 128 | 9.3 | 1 | 0.1 | 313 | 22.8 |
| 300 | 154 | 11.2 | 86 | 6.3 | 137 | 10.0 | 173 | 12.6 | 550 | 40.1 |
| 400 | 82 | 6.0 | 55 | 4.0 | 70 | 5.1 | 107 | 7.8 | 314 | 22.9 |
| 500 | 16 | 1.2 | 10 | 0.7 | 27 | 2.0 | 74 | 5.4 | 127 | 9.3 |
| M.Sc. 1 | 35 | 2.6 | 0 | 0.0 | 14 | 1.0 | 1 | 0.1 | 50 | 3.6 |
| M.Sc. 11 | 14 | 1.0 | 0 | 0,0 | 4 | 0.3 | 0 | 0.0 | 8 | 1.3 |
| **Total** | **410** | **29.9%** | **226** | **16.5%** | **380** | **27.7%** | **356** | **25.9%** | **1372** | **100%** |
| **Weight (KG)** | | | | | | | | | | |
| 40 and below | 12 | 0.9 | 8 | 0.6 | 13 | 0.9 | 0 | 0.0 | 33 | 2.4 |
| 41-50 | 68 | 5.0 | 68 | 5.0 | 66 | 4.8 | 20 | 1.5 | 222 | 16.2 |
| 51-60 | 116 | 8.5 | 74 | 5.4 | 115 | 8.4 | 60 | 4.9 | 372 | 27.1 |
| 61-70 | 104 | 7.6 | 48 | 3.5 | 97 | 7.1 | 126 | 9.2 | 375 | 27.3 |
| 71-80 | 51 | 3.7 | 28 | 2.0 | 54 | 3.9 | 143 | 10.4 | 276 | 20.1 |
| 81-90 | 41 | 3.0 | 0 | 0.0 | 22 | 1.6 | 0 | 0.0 | 63 | 4.6 |
| 91-100 | 16 | 1.2 | 0 | 0.0 | 10 | 0.7 | 0 | 0.0 | 26 | 1.9 |
| 100 and above | 2 | 0.1 | 0 | 0.0 | 3 | 0.2 | 0 | 0.0 | 5 | 0.4 |
| **Total** | **410** | **29.9%** | **226** | **16.5%** | **380** | **27.7%** | **356** | **25.9%** | **1372** | **100%** |

**Source:** Researcher's Field Survey, 2024

**Table 4.5:** Socio-economic Attributes of the Resident Students in Hostel Rooms

| **Variable** | **Institution** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **No of occupants in hostel room** | **University of Ibadan** | | **Abiola Ajimobi Technical University** | | **Lead City University** | | **Ajayi Crowther University** | | **Total** | |
| | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** |
| 1-2 students | 87 | 6.3 | 0 | 0.0 | 92 | 6.7 | 13 | 0.9 | 192 | 14.0 |
| 3-4 students | 234 | 17.1 | 226 | 16.5 | 253 | 18.4 | 160 | 11.7 | 873 | 63.6 |
| 5-6 students | 69 | 5.0 | 0 | 0.0 | 28 | 2.0 | 132 | 9.6 | 229 | 16.7 |
| 7-8 students | 17 | 1.2 | 0 | 0.0 | 5 | 0.4 | 13 | 0.9 | 35 | 2.6 |
| More than 8 students | 3 | 0.2 | 0 | 0.0 | 2 | 0.1 | 38 | 2.8 | 43 | 3.1 |
| **Total** | **410** | **29.9** | **226** | **16.5** | **380** | **27.7** | **356** | **25.9** | **1372** | **100.0** |
| **Period of occupancy** | | | | | | | | | | |
| 1-2 months | 12 | 0.9 | 9 | 0.7 | 24 | 1.7 | 37 | 2.7 | 82 | 6.0 |
| 3-4 months | 69 | 5.0 | 131 | 9.5 | 75 | 5.5 | 137 | 10.0 | 412 | 30.0 |
| 5-6 months | 60 | 4.4 | 28 | 2.0 | 56 | 4.1 | 92 | 6.7 | 236 | 17.2 |
| 7-8months | 79 | 5.8 | 21 | 1.5 | 63 | 3.9 | 34 | 2.5 | 187 | 13.6 |
| 9-10months | 86 | 6/3 | 10 | 0.7 | 92 | 6.7 | 0 | 0.0 | 188 | 13.7 |
| 11-12months | 104 | 7.6 | 27 | 2.0 | 80 | 5.8 | 56 | 4.1 | 267 | 19.5 |
| **Total** | **410** | **29.9** | **226** | **16.5** | **380** | **27.7** | **356** | **25.9** | **1372** | **100.0** |
| **Time of day mostly spent in hostel** | | | | | | | | | | |
| Morning | 56 | 4.1 | 17 | 1.2 | 62 | 4.5 | 157 | 10.0 | 272 | 19.8 |
| Afternoon | 65 | 4.7 | 0 | 0.0 | 17 | 3.9 | 1 | 0.1 | 120 | 8.7 |
| Night | 289 | 21.1 | 209 | 15.2 | 264 | 19.2 | 218 | 15.9 | 980 | 71.4 |
| **Total** | **410** | **29.9** | **226** | **16.5** | **380** | **27.7** | **356** | **25.9** | **1372** | **100.0** |
| **Average duration of time spent in hostel** | | | | | | | | | | |
| 3-5hours | 42 | 3.1 | 34 | 2.5 | 63 | 4.6 | 13 | 0.9 | 152 | 11.1 |
| 6-7hours | 145 | 10.6 | 85 | 6.2 | 148 | 10.8 | 115 | 8.4 | 493 | 35.9 |
| 9-11hours | 145 | 10.6 | 53 | 3.9 | 107 | 7.8 | 105 | 7.7 | 410 | 29.9 |
| 12-14 hours | 64 | 4.7 | 37 | 2.7 | 48 | 3.5 | 60 | 4.4 | 209 | 15.2 |
| 15-17hours | 14 | 1.0 | 17 | 1.2 | 14 | 1.0 | 63 | 4.6 | 108 | 7.9 |
| **Total** | **410** | **29.9** | **226** | **16.5** | **380** | **27.7** | **356** | **25.9** | **1372** | **100.0** |

**Source:** Researcher's Field Survey, 2024

For number of occupants in hostel room, results (Table 4.5) indicated that more than half (63.6%) of the respondents stated that between 3-4 students occupied a room; 16.7% between 5-6 students; 14% between 1-2 students; 3.1% more than eight (8) students and

2.6% between 7-8 students. Out of 63.6% of respondents who stated that occupants in their room ranged between 3-4, 18.4% and 17.1% respectively are from Lead City University and University of Ibadan. Ajayi Crowther University accounts for majority (2.8%) of the total percentage (3.1%) of those with more than eight (8) students in a room. Results in Table 4.5 showed that about 30% have stayed between 3-4 months in the hostel room; 19.5% have stayed between 11-12 months; 17.2% between 5-6months; 13.7% between 9-10 months; 13.6% between 7-8 months and 6% between 1-2 months.

Breakdown of the results based on institution, shows that one-third (10%) of the total percentage (30%) of respondents who have stayed between 3-4 months in the hostel room are from Ajayi Crowther University, while 7.6% of those who have stayed between 11-12 months are from University of Ibadan. Again, the result revealed that about two-third (71.4%) of the respondents agreed that time of the day mostly spent in the hostel room is night. Less than one-fifth (19.8%) spend morning period in the hostel room, while about 8.7% spend afternoon period.



The result of the socio-economic characteristics of students across four institutions under study showed diversity in age, gender and body weight. For instance, in term of age difference, older adults may be more sensitive to temperature extremes and required more lighting due to declining vision while younger occupants preferred cooler temperatures and brighter or more flexible lighting[17]. As for gender, males and females may have different temperature preferences, with females preferring warmer temperatures than males. Females are also more sensitive to lighting levels and types in spaces[17]. Furthermore, individuals with higher body weight, shape and size exhibit different metabolic rates, influencing heat loss with diverse temperatue preferences[17]. Age and gender differences also influence diverse sensitivities to noise levels and types. These results of diversities are in conformity with earlier research that, if indoor conditions were the same, occupants can have diverse perceptions resulting to different responses[17]. Therefore, the implication in practical term is that, there may be existence of significant differences in the responses of the occupants to IEQ conditions (thermal lighting, indoor air quality and acoustic) in the hostel rooms across all institutions under study.

The analysis further revealed that majority of the students residing in the hostels across the four institutions have spent at least one (1) academic session in the institution's hostel with averagely occupancy periods of 3-4 months in the second academic session at the time of this study. It implies that the occupants in all study areas across the institutions had familiarized themselves with the indoor conditions of their hostel rooms. This coincided with previous studies that, the respondents' occupancy time in hostels is associated with their deep experience to indoor environmental quality of their rooms/ambiences[18]. It is further shown that majority of the respondents (81%) spent an average of 25-60% (6-14hours) daily in the hostels after daily academic activities, especially 71.4% of the students stay indoors at night till dawn, for their next daily academic activities to commence. The result is similar to the previous findings of students' typical living conditions that students are spending more of their daytime in hostel room than in the classrooms or inside school buildings/premises [18, 19, 20]. Regarding the number of students residing in hostel room, the result found that about 3-4 students (63.6%) stayed in a room. It implies that, all hostel rooms under study are not over-capacitated. This finding is against the overcrowding issue that was noted with hostel rooms in the previous studies, which stated that, the high occupancy rate may result to dissatisfaction, discomfort, poor wellbeing and low productivity [18, 21].

#### 4.1.3.2 Level of Satisfaction with Indoor Environmental Conditions in the Hostels

The major thrust of this section is to examine how respondents across the four higher institutions of learning in the study area perceived satisfaction with the IEQ components in their hostel room. Thus, a cross-tabulation and chi-square test was performed on each IEQ component.

##### 4.1.3.2.1 Level of Satisfaction with Thermal Comfort

##### 4.1.3.2.1.1 Thermal Sensation

Results in Table 4.6 indicated that, 32.1% perceived the thermal sensation in their hostel room in the morning to be cool, 22.7% slightly cool, 25.8% cold, 3.9% hot, 9% neutral, 3.4% slightly warm and 3.1% warm. A further breakdown of the results based on institution, shows that 10.8% of 32.1% respondents who perceived the thermal sensation in their hostel to be cool in the morning are from University of Ibadan, while 2.8% of the total percentage (3.9%) who perceived thermal sensation in their hostel room as being hot in the morning are from Ajayi Crowther University. The Chi-square statistics in Table 4.6 revealed that at 0.05 level of significance, significant differences exist in the perception of respondents across the four institutions on thermal sensation in the morning period ($X=172.462^a$, $p<0.05$). Hence, across all the institutions under study, 35.1% of the students perceived thermal sensation within the centrally comfort zones of slightly cool, Neutral and slightly warm is lower than 80% thermal acceptable standard.

**Table 4.6:** Students' Satisfaction with Thermal Sensation

| Items | Name of the Institution | | | | Total | Chi-Square (X) | Sig |
|---|---|---|---|---|---|---|---|
| | University of Ibadan | Abiola Ajimobi Technical University, Ibadan | Lead city University, Ibadan | Ajayi Crowther University, Oyo | | | |
| | **F (%)** | **F (%)** | **F (%)** | **F (%)** | **F (%)** | | |
| | | | **Morning** | | | | |
| Cold | 93 (6.8%) | 32 (2.3%) | 111 (8.1%) | 118(8.6%) | 354(25.8%) | | |
| Cool | 148 (10.8%) | 104 (7.6%) | 129(9.4%) | 59(4.3%) | 440(32.1%) | | |
| Slightly Cool | 94(6.9%) | 51(3.7%) | 76 (5.5%) | 90 (6.6%) | 311 (22.7%) | | |
| Neutral | 39(2.8%) | 11(0.8%) | 36 (2.6%) | 38(2.8%) | 124(9.0%) | | |
| Slightly Warm | 16(1.2%) | 19(1.4%) | 11(0.8%) | 1(0.1%) | 47(3.4%) | 172.462[a] | .000** |
| Warm | 18(1.3%) | 0(0.0%) | 13(0.9%) | 12(0.9%) | 43(3.1%) | | |
| Hot | 2(0.1%) | 9(0.7%) | 4(0.3%) | 38(2.8%) | 53(3.9%) | | |
| **Total** | **410(29.9%** | **226(16.5%** | **380(27.7%** | **356(25.9%** | **1372(100%** | | |
| | | | **Afternoon** | | | | |
| Cold | 22(1.6%) | 20(1.5%) | 31(2.3%) | 6(0.4%) | 79(5.8%) | | |
| Cool | 40(2.9%) | 15(1.1%) | 59(4.3%) | 146(10.6%) | 260(19.0%) | | |
| Slightly Cool | 71(5.2%) | 39(2.8%) | 81(5.9%) | 38(2.8%) | 229(16.7%) | | |
| Neutral | 67(4.9%) | 14(1.0%) | 63(4.6%) | 26(1.9%) | 170(12.4%) | | |
| Slightly Warm | 86(6.3%) | 46(3.4%) | 56(4.1%) | 23(1.7%) | 211(15.4%) | 250.990[a] | .000** |
| Warm | 100(7.3%) | 83(6.0%) | 72(5.2%) | 78(5.7%) | 333 (24.3%) | | |
| Hot | 24(1.7%) | 9(0.7%) | 18(1.3%) | 39(2.8%) | 90(6.6%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100%)** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Night** | | | | |
| Cold | 64 (4.7%) | 26(1.9%) | 60(4.4%) | 88(6.4%) | 238(17.3%) | | |
| Cool | 118(8.6%) | 41(3.0%) | 107(7.8%) | 12(0.9%) | 278(20.3%) | | |
| Slightly Cool | 82(6.0%) | 51(3.7%) | 82(6.0%) | 103(7.5%) | 318(23.2%) | 221.806[a] | .000** |
| Neutral | 60(4.4%) | 30(2.2%) | 67(4.9%) | 12(0.9%) | 169(12.3%) | | |
| Slightly Warm | 50 (3.6%) | 38 (2.8%) | 40(2.9%) | 49(3.6%) | 177(12.9%) | | |
| Warm | 34 (2.5%) | 31(2.3%) | 18(1.3%) | 54(3.9%) | 137(10.0%) | | |
| Hot | 2(0.1%) | 9(0.7%) | 6(0.4%) | 38(2.8%) | 55(4.0%) | | |
| **Total** | **410(29.9%** | **226(16.5%** | **380(27.7%** | **356(25.9%** | **1372(100%** | | |

Statistics significant at 0.05**

**Source:** Researcher's Field Survey, 2024

Furthermore, the perception of respondents on thermal sensation in the afternoon was examined. Results in Table 4.6 indicated that 24.3% of respondents across the four institutions perceived thermal sensation in the afternoon to be warm, 19% cool, 16.7% slightly cool, 12.4% neutral, 15.4% slightly warm, and 6.6% hot. The percentage of respondents that perceived thermal sensation to be warm in the afternoon is a little bit higher in University of Ibadan (7.3%) compared to Abiola Ajimobi Technical University (6%), Ajayi Crowther University (5.7%) and Lead City University (5.2%). Again, the percentage of respondents from Ajayi Crowther University that perceived the thermal sensation in the afternoon to be hot is higher (2.8%) when compared to other three institutions that scored less than one percent. Chi-square statistics equally shows that there is significant difference in perception of thermal sensation in the afternoon across the institutions ($X = 250.990^a$, $p<0.05$). However, 44.5% respondents perceived thermal sensation in the afternoon to be slightly cool, neutral and slightly warm (centrally comfort zone), falling short of 80% thermal acceptable criterion.

Likewise, 23.2% of respondents perceived the thermal sensation at night to be slightly cool, while 20.3% and 17.3% perceived it to be cool and cold respectively. About 10% perceived thermal sensation at night to be warm, while 4% perceived it hot. Also, the Chi-square statistics revealed that the significant differences exist in the level of perception of thermal sensation at night across the institutions in the study area ($X = 221.806^a$, $p<0.05$). However, within the three centrally comfort zone (slightly cool, neutral and slightly warm), a total of 48.4% respondents perceived thermal sensation at night, thereby lesser than 80% acceptable standard.

Summarily, the results of the findings confirmed that the highest percentages (32.1%) of the students are of opinion that their rooms are cool in the morning and slightly cool at night (23.2%), however, warm in the afternoon (24.3%). Despite the coolness of the rooms in the morning and night, the result revealed that all the hostel occupants are thermally unsatisfied and uncomfortable throughout the day. This is due to the fact that, the overall votes (35.1%) of the students voted within the centrally comfort zones of slightly cool, Neutral and slightly warm categories (+1, 0, -1) is lower than 80% thermal acceptable standard. The thermal environment is said to be uncomfortable. It implies that, uncomfortable indoors can affect the satisfaction, productivity and well-being of the occupants. This validates earlier study that, when the overall assessment of the occupants throughout the day fell below the 80% acceptability criterion, recommended by American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) standard, the indoor environment is uncomfortable and unsatisfactory [22].

**4.1.3.2.1.2 Thermal Preference**

The next thermal attribute examined is thermal preference of the respondents. Results in Table 4.7 indicated that one-third (35.6%) of the respondents prefer their hostel temperature in the morning to be cooler, while 30.9% and 19.5% prefer it to be much cooler and neutral respectively. Very few (8.7% & 5.2%) perceived the hostel temperature in the morning to be either warmer or much warmer. The percentage of respondents from Ajayi Crowther University who perceived the hostel room to be much cooler in the morning is higher (13.5%) compared to University of Ibadan (5.4%), Abiola Ajimobi Technical University (3.4%) and Lead City University (8.7%). Significant difference exists in level of students' perception to thermal preference in the morning across the institutions ($X=195.615^a$, $p<0.05$). This is due to existence of diversity in age, gender and body mass among the occupants of the hostel rooms.

**Table 4.7:** Students' Thermal Preference

| Items | Name of the Institution | | | | Total | Chi-Square (X) | Sig |
|---|---|---|---|---|---|---|---|
| | University of Ibadan | Abiola Ajimobi Technical University, Ibadan | Lead city University, Ibadan | Ajayi Crowther University, Oyo | | | |
| | F (%) | F (%) | F (%) | F (%) | F (%) | | |
| **Morning** | | | | | | | |
| Much cooler | 74(5.4%) | 46(3.4%) | 119(8.7%) | 185(13.5%) | 424(30.9%) | | |
| Cooler | 166(12.1%) | 108(7.9%) | 120(8.7%) | 95(6.9%) | 489(35.6%) | 195.615[a] | .000** |
| No change | 108(7.9%) | 36(2.6%) | 85(6.2%) | 39(2.8%) | 268(19.5%) | | |
| Warmer | 49(3.6%) | 28(2.0%) | 42(3.1%) | 0(0.0%) | 119(8.7%) | | |
| Much warmer | 13(0.9%) | 8(0.6%) | 14(1.0%) | 37(2.7%) | 72(5.2%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9)** | **1372(100.0%** | | |
| | **Afternoon** | | | | | | |
| Much cooler | 96(7.0%) | 48(3.5%) | 84(6.1%) | 73(5.3%) | 301(21.9%) | | |
| Cooler | 169(12.3%) | 123(9.0%) | 148(10.8%) | 189(13.8%) | 629(45.8%) | | .000** |
| No change | 84(6.1%) | 51(3.7%) | 81(5.9%) | 42(3.1%) | 258(18.8%) | 57.346[a] | |
| Warmer | 47(3.4%) | 1(0.1%) | 49(3.6%) | 40(2.9%) | 137(10.0%) | | |
| Much warmer | 14(1.0%) | 3(0.2%) | 18(1.3%) | 12(0.9%) | 47(3.4%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%** | **1372(100%)** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Night** | | | | |
| Much cooler | 80(5.8%) | 17(1.2%) | 102(7.5%) | 133(9.7%) | 332(24.3%) | | |
| Cooler | 168(12.3%) | 154(11.2%) | 134(9.8%) | 78(5.7%) | 534(39.0%) | | |
| No change | 95(6.9%) | 36(2.6%) | 74(5.4%) | 101(7.4%) | 306(22.4%) | 222.491[a] | .000** |
| Warmer | 52(3.8%) | 18(1.3%) | 56(4.1%) | 6(0.4%) | 132(9.6%) | | |
| Much warmer | 15(1.1%) | 1(0.1%) | 11(0.8%) | 38(2.8%) | 65(4.7%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%** | **1372(100.0)** | | |

Statistics significant at 0.05**
**Source:** Researcher's Field Survey, 2024

Relatedly, 45.8% and 39% respectively perceived the thermal preference in the afternoon and night to be cooler, while 21.9% and 24.3% perceived it to be much cooler. Furthermore, in the afternoon and night, about 18.8% and 22.4% responded No change, while 10% and 9.6% perceived the room temperature to be warm, 3.4% and 4.7% accepted it to be much warmer respectively. The chi –square statistics revealed that respondents perception of thermal preference in the afternoon ($X= 57.346^a$, $p<0.05$) and night ( $X = 222.491^a$, $p<0.05$) differs significantly across the four institutions.

However, across the four institutions under study, total of 63.8%, 64.6% and 71% students perceived within centrally comfort zone of cooler, no change and warmer in the morning, afternoon and night respectively, each falling below 80% ASHRAE acceptable standard.

In summary, the findings showed that majority of the residents in the hostels indicated that, cool thermal environment is preferable throughout the day (i.e. morning (35.6%), afternoon (45.8%) and night (39.0%)) despite the unsatisfactory ambiences. Though, these percentages do not make up half of the respondents, thus implies that the hostel rooms are not fully thermally preferable and conducive. This supports the assertion that, the occupants of hostels responded differently due to diverse perceptions, sometimes with wide preferences (such as age, gender, body weight etc) to the thermal indoor conditions as a result of highly unsatisfactory thermal conditions in many naturally ventilated university dormitories[23].



**4.1.3.2.1.3 Room Air Quality/Movement**

For room air quality/movement in the hostel room, Table 4.8 result below indicated that one-third (36.9%) of respondents across the four institutions rated the room air movement in the morning as good, 23.6% rated it excellent, 17.8% rated it as very good, 15.5% fair and 6.3% poor. Out of 23.6% of respondents that rated room air quality in the hostel as excellent, Ajayi Crowther University have higher percentage (9.7%), followed by Lead City University (7%), University of Ibadan (4%) and Abiola Ajimobi Technical University (2.8%). The percentage of respondents that perceived room air quality in the hostel as poor, is higher in Abiola Ajimobi Technical University (2.2%) compared to University of Ibadan (1.6%), Lead City University (1.5%) and Ajayi Crowther University (0.9%).

**Table 4.8:** Room Air Quality

| Items | Name of the Institution | | | | Total | Chi-Square (X) | Sig |
|---|---|---|---|---|---|---|---|
| | University of Ibadan | Abiola Ajimobi Technical University, Ibadan | Lead city University, Ibadan | Ajayi Crowther University, Oyo | | | |
| | F (%) | F (%) | F (%) | F (%) | F (%) | | |
| | | | **Morning** | | | | |
| Excellent | 55(4.0%) | 39(2.8%) | 96(7.0%) | 133(9.7%) | 323(23.6%) | | |
| Very good | 83(6.1%) | 23(1.7%) | 84(6.1%) | 54(3.9%) | 244(17.8%) | | |
| Good | 151(11.0%) | 110(8.0%) | 125(9.1%) | 120(8.8%) | 506(36.9%) | 129.487[a] | .000** |
| Fair | 99(7.2%) | 24(1.8%) | 54(3.9%) | 36(2.6%) | 213(15.5%) | | |
| Poor | 22(1.6%) | 30(2.2%) | 21(1.5%) | 13(0.9%) | 86(6.3%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |
| | | | **Afternoon** | | | | |
| Excellent | 32(2.3%) | 42(3.1%) | 48(3.5%) | 65(4.7%) | 187(13.6%) | | |
| Very good | 54(3.9%) | 36(2.6%) | 66(4.8%) | 104(7.6%) | 260(19.0%) | | |
| Good | 115(8.4%) | 82(6.0%) | 135(9.8%) | 81(5.9%) | 413(30.1%) | 119.150[a] | .000** |
| Fair | 161(11.7%) | 29(2.1%) | 87(6.3%) | 67(4.9%) | 344(25.1%) | | |
| Poor | 48(3.5%) | 37(2.7%) | 44(3.2%) | 39(2.8%) | 168(12.3%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |
| | | | **Night** | | | | |
| Excellent | 40(2.9%) | 61(4.4%) | 65(4.7%) | 53(3.9%) | 219(16.0%) | | |
| Very good | 74(5.4%) | 16(1.2%) | 76(5.5%) | 81(5.9%) | 247(18.0%) | | |
| Good | 156(11.4%) | 75(5.5%) | 144(10.5%) | 126(9.2%) | 501(36.5%) | 87.579[a] | .000** |
| Fair | 103(7.5%) | 28(2.0%) | 65(4.7%) | 60(4.4%) | 256(18.7%) | | |

| | | | | | |
|---|---|---|---|---|---|
| Poor | 37(2.7%) | 46(3.4%) | 30(2.2%) | 36(2.6%) | 149(10.9%) |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** |

Statistics significant at 0.05**
**Source:** Researcher's Field Survey, 2024

In the further analysis of Table 4.8; during the afternoon and night periods, 30.1% and 36.5% respectively perceived the room air movement to be good, while 13.6% and 16% perceived it as excellent. In the afternoon, the percentage of respondents who perceived the room air quality as good is higher in Lead City University (9.8%) compared to Ajayi Crowther University (5.9%), Abiola Ajimobi Technical University (6%) and University of Ibadan (8.4%). In the evening time, the percentage of respondents from University of Ibadan who rated air quality in their hostel room as good is higher (11.4%) compared to others. In general, Chi-square statistics in Table 4.8 showed that, there is significant difference in the rating (perception) of air quality in hostel room in the afternoon ($X=119.150^a, p<0.05$) and night ($X=87.579^a, p<0.05$) across the four institutions in the study area.

Nonetheless, the findings of this research affirmed that majority of the hostel occupants across the four institutions are of opinion that the quality of air movement in all the hostel rooms is either very good or good and therefore, desirable for all the sessions of the day i.e. morning; afternoon and night. This suggests that the ventilation rate/air speed is highly felt and desirable for all the occupants of the hostels for the greater periods of the day. This finding is against the previous research conducted in a naturally-ventilated hostel of other part of the region that low/inadequate of ventilation flow was the cause of the discomfort experienced by the occupants [24, 16].

**4.1.3.2.1.4 Moisture in Air/Humidity**

The next thermal attribute examined is air moisture/rate of humidity in the hostel room. Table 4.9 results indicated that 10.7% of respondents perceived air moisture in their hostel room during morning period to be humid, while 22.7% perceived it to be slightly humid, 23.6% neutral, 19.5% slightly dry and 23.5% dry. Respondents across the institutions varied in their perception of air moisture in the hostel room. For example, percentage of respondents who perceived air moisture as slightly humid is a bit higher (7.7%) in University of Ibadan compared to the other institutions (Lead City University (5.3%), Ajayi Crowther University (5.2%), Abiola Ajimobi Technical University (4.4%).

In the afternoon session, the results indicated that 7.2% perceived air moisture in the room to be humid, 17% perceived it to be slightly humid, 24.9% no change, 37.2% slightly dry and 13.8% dry. More respondents from Ajayi Crowther University (16.6%) perceived the air moisture in their hostel to be slightly dry compared to respondents from the other institutions. In terms of being dry, results show that the respondents' percentage from University of Ibadan (6%) and Lead City University (5.5%) is higher compared to Abiola Ajimobi Technical University (2.1%) and Ajayi Crowther University ( 0.1%). It suggests that hostel rooms in University of Ibadan and Lead City University are perceived to be dry at the afternoon time, when compared to the other two institutions in the research area.

At night, 9.8% and 26.1% of respondents perceived the room air moisture to be humid and slightly humid respectively, 28.9% as no change, 21.1% slightly dry and 14.1% dry. 7.5% out of 26.1% that perceived room air moisture as slightly humid are from University of Ibadan, 7.1% from Ajayi Crowther University, 6.2% from Lead City University and 5.1% from Abiola Ajimobi Technical University. In general, the chi-square test reveals that significant differences exist in the respondents' perception across the four institutions on air moisture in hostel room in the morning ($X = 67.881^a$, $p<0.05$), afternoon ( $X = 217.603^a$ , $p<0.05$), and night ($X = 59.734^a$, $p<0.05$). Across all the four institutions, the voting within the comfort limit zone of slightly humid, no change and slightly dry in the morning, afternoon, and night periods are 65.8%, 79.1% and 76.1% respectively, lessened than 80% ASHRAE acceptable/satisfactory standard.

The findings summarized the analysis that, the occupants of the dormitories across all four institution agreed that the relative humidity of the rooms are either dry or slightly dry during the morning (43%) and afternoon (60%) periods while slightly humid or humid (35.9%) at night time. However, it is affirmed that the relative humidity rating within the central categories of -1, 0 and +1 during the whole day fall below 80% ASHRAE standard. It therefore signifies that occupants of the hostels were highly dissatisfied with the relative humidity level in their rooms for almost all periods of the day. This result is in conformity with the previous study that the indoor relative humidity is below ASHRAE standard and most of hostel occupants were less comfortable and satisfactory with the immediate thermal environment[23]. It is also in line with another finding that building users are dissatisfied with existing humid indoor conditions caused by interactions of local outdoor climate conditions[25].

**Table 4.9:** Air Moisture/Humidity in the Room

| Items | Name of the Institution | | | | Total | Chi-Square (X) | Sig |
|---|---|---|---|---|---|---|---|
| | University of Ibadan | Abiola Ajimobi Technical University, Ibadan | Lead city University, Ibadan | Ajayi Crowther University, Oyo | | | |
| | F (%) | F (%) | F (%) | F (%) | F (%) | | |
| | | | **Morning** | | | | |
| Humid | 39 (2.8%) | 27 (2.0%) | 27(2.0%) | 54(3.9%) | 147(10.7%) | | |
| Slightly humid | 106(7.7%) | 61(4.4%) | 73(5.3%) | 71(5.2%) | 311(22.7%) | | |
| No change | 112(8.2%) | 51(3.7%) | 101(7.4%) | 60(4.4%) | 324(23.6%) | 67.881[a] | .000** |
| Slightly dry | 88(6.4%) | 47(3.4%) | 83(6.0%) | 50(3.6%) | 268(19.5%) | | |
| Dry | 65(4.7%) | 40(2.9%) | 96(7.0%) | 121(8.8%) | 322(23.5%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |
| | | | **Afternoon** | | | | |
| Humid | 44(3.2%) | 9(0.7%) | 26(1.9%) | 20(1.5%) | 99(7.2%) | | |
| Slightly humid | 73(5.3%) | 49(3.6%) | 48(3.5%) | 63(4.6%) | 233(17.0%) | 217.603[a] | .000** |
| No change | 110(8.0%) | 66(4.8%) | 121(8.8%) | 44(3.2%) | 341(24.9%) | | |
| Slightly dry | 100(7.3%) | 73(5.3%) | 109(7.9%) | 228(16.6%) | 510(37.2%) | | |
| Dry | 83(6.0%) | 29(2.1%) | 76(5.5%) | 1(0.1%) | 189(13.8%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |
| | | | **Night** | | | | |
| Humid | 46(3.4%) | 19(1.4%) | 39(2.8%) | 31(2.3%) | 135(9.8%) | | |
| Slightly humid | 103(7.5%) | 73(5.3%) | 85(6.2%) | 97(7.1%) | 358(26.1%) | 59.734[a] | .000** |
| No change | 122(8.9%) | 78(5.7%) | 125(9.1%) | 71(5.2%) | 396(28.9%) | | |
| Slightly dry | 93(6.8%) | 43(3.1%) | 81(5.9%) | 73(5.3%) | 290(21.1%) | | |
| Dry | 46(3.4%) | 13(0.9%) | 50(3.6%) | 84(6.1%) | 193(14.1%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |

**Source:** Researcher's Field Survey, 2024

#### 4.1.3.2.1.5 Overall Thermal Comfort in Hostel Room

In investigating the perception of respondents on the overall thermal conditions in their hostel room, table 4.10a result indicated that 8.5% of respondents perceived that the overall thermal condition in their hostel room is very uncomfortable, while 27.5% perceived it to be slightly uncomfortable, 39.9% as neutral, 19.4% as slightly comfortable and 4.7% as very comfortable.

One-way analysis of variance (ANOVA) test was also performed to examine whether significant difference exists in the overall comfort of the respondents based on group mean scores obtained for each institution (Table 4.10b). Results indicated that there is significant difference on assessment of overall thermal comfort across the four institutions (F= 43.072, $p<0.05$).

**Table 4.10a:** Assessment of Overall Thermal Comfort in Hostel Room

| Items | Name of the Institution | | | | Total |
|---|---|---|---|---|---|
| | **University of Ibadan** | **Abiola Ajimobi Technical University, Ibadan** | **Lead city University, Ibadan** | **Ajayi Crowther University, Oyo** | |
| | **F (%)** | **F (%)** | **F (%)** | **F (%)** | **F (%)** |
| Very Uncomfortable | 35 (2.6%) | 20 (1.5%) | 25(1.8%) | 37(2.7%) | 117(8.5%) |
| Slightly Uncomfortable | 114(8.3%) | 43(3.1%) | 74(5.4%) | 147(10.7%) | 378(27.5%) |
| Neutral | 163(11.9%) | 60(4.4%) | 158(11.5%) | 166(12.1%) | 547(39.9%) |
| Slightly Comfortable | 84(6.1%) | 87(6.3%) | 90(6.6%) | 5(0.4%) | 266(19.4%) |
| Very Comfortable | 14(1.0%) | 16(1.2%) | 33(2.4%) | 1(0.1%) | 64(4.7%) |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** |

**Source:** Researcher's Field Survey, 2024

**Table 4.10b:** Assessment of Overall Thermal Comfort in Hostel Room

| Institution | Mean | Std. Deviation | Std. Error | F | Sig | Tukey B Post-hoc homogenous subsets | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Sub-set 1 | Sub-set 2 | Sub-set 3 |
| University of Ibadan | 2.82 | .966 | .048 | 43.07 2 | .000** | | 2.82 | |
| Abiola Ajimobi Technical University, Ibadan | 3.16 | 1.092 | .073 | | .000** | | | 3.16 |
| Lead city University, Ibadan | 3.08 | 1.019 | .052 | | .000** | | | 3.08 |
| Ajayi Crowther University, Oyo | 2.40 | .703 | .037 | | .000** | 2.40 | | |
| **Total** | **2.84** | **.986** | **.027** | | | | | |

**Source:** Researcher's Field Survey, 2024

A closer look at the mean scores obtained for each institution in Table 4.10b showed that respondents from Abiola Ajimobi Technical University (mean=3.16) and Lead City University (mean =3.08) scored higher than respondents from University of Ibadan (mean= 2.8) and Ajayi Crowther University (mean = 2.4). Level of thermal comfort was rated on a 5 point Likert scale ranging from 1= very uncomfortable to 5=very comfortable. Against this backdrop, it could be said that respondents from Abiola Ajimobi Technical University and Lead City University rated overall thermal comfort in their hostel room as slightly-comfortable, while those from University of Ibadan and Ajayi Crowther University rated overall thermal comfort in their hostel room as slightly uncomfortable.

However, in Table 4.10a, the result presented that 36% of the hostel occupants found their overall thermal conditions unacceptable and uncomfortable while 39.9% are neutral with the lowest percentage of 24.1% respondents claiming the overall thermal condition as comfortable and satisfactory due to significant differences exist in response to indoor conditions. Therefore, the result shows that the occupants are unsatisfactory and uncomfortable with the existing thermal environmental conditions of their hostel rooms. Therefore, this statement is consistent with previous study establishing that, the occupants were mostly thermally uncomfortable with the existing thermal environments in a naturally ventilated hostels[26, 27].



**4.1.3.2.2 Level of Satisfaction with Indoor Air Quality in Hostel Room**

Results in Table 4.11a showed the students responses toward the frequency of windows opening in the hostel rooms across the four institutions under study. 33.4% of the respondents indicated that the windows are "always opened"; 32.7% indicated as "often opened"; 21.4% claimed the windows as "sometimes opened"; 8.5% as "rarely opened" and 4% indicated the windows opening as "never"

**Table 4.11a:** Frequency of Window Opening in Hostel Room

| Items | Name of the Institution | | | | Total |
|---|---|---|---|---|---|
| | University of Ibadan | Abiola Ajimobi Technical University, Ibadan | Lead city University, Ibadan | Ajayi Crowther University, Oyo | |
| | **F (%)** | **F (%)** | **F (%)** | **F (%)** | **F (%)** |
| Never | 10 (0.7%) | 4 (0.3%) | 17(1.2%) | 24(1.7%) | 55(4.0%) |
| Rarely | 46(3.4%) | 28(2.0%) | 37(2.7%) | 6(0.4%) | 117(8.5%) |
| Sometimes | 88(6.4%) | 42(3.1%) | 103(7.5%) | 61(4.4%) | 294(21.4%) |
| Often | 121(8.8%) | 89(6.5%) | 88(6.4%) | 150(10.9%) | 448(32.7%) |
| Always | 145(10.6%) | 63(4.6%) | 135(9.8%) | 115(8.4%) | 458(33.4%) |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** |

**Source:** Researcher's Field Survey, 2024

The results in Table 4.11b indicated that, one-third (34.7%) of respondents across the four institutions rated that the quality of air in their room as Not smelly, 21.2% Moderately smelly, 19.5% Slightly smelly, 17.4% Not smelly at all and 7.3% Extremely smelly. The breakdown of results show that the percentage of respondents who perceived the indoor air quality in their hostel room as extremely smelly is higher in University of Ibadan when compared to others. In contrast, the percentage of respondents who perceived the room air quality as Not smelly at all is higher in Lead City University when compared to others. The Chi-square statistics show that there is significant difference in the perception of respondents across the four institutions on air quality in hostel room ($X = 140.922^a$, $p<0.05$).

**Table 4.11b:** Air Quality in Room

| Items | Name of the Institution: University of Ibadan | Abiola Ajimobi Technical University, Ibadan | Lead city University, Ibadan | Ajayi Crowther University, Oyo | Total | Chi-Square (X) | Sig |
|---|---|---|---|---|---|---|---|
| | F (%) | F (%) | F (%) | F (%) | F (%) | | |
| **SMELL** | | | | | | | |
| Extremely smelly | 26(1.9%) | 27(2.0%) | 22(1.6%) | 25(1.8%) | 100(7.3%) | | |
| Moderately smelly | 72(5.3%) | 25(1.8%) | 67(4.9%) | 126(9.1%) | 290(21.2%) | 140.922[a] | .000 |
| Slightly smelly | 104(7.6%) | 53(3.9%) | 76(5.5%) | 34(2.5%) | 267(19.5%) | | |
| Not smelly | 137(10.0%) | 81(5.9%) | 110(8.0%) | 148(10.8%) | 476(34.7%) | | |
| Not at all smelly | 71(5.2%) | 40(2.9%) | 105(7.7%) | 23(1.7%) | 239(17.4%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |
| **DUST** | | | | | | | |
| Extremely dusty | 16(1.2%) | 1(0.1%) | 11(0.8%) | 0(0.0%) | 28(2.0%) | | |
| Moderately dusty | 76(5.5%) | 10(0.7%) | 64(4.7%) | 25(1.8%) | 175(12.8%) | | |
| Somewhat dusty | 81(5.9%) | 15(1.1%) | 80(5.9%) | 104(7.6%) | 280(20.5%) | | |
| Slightly dusty | 100(7.3%) | 91(6.7%) | 140(10.2%) | 143(10.5%) | 474(34.7%) | 144.437[a] | .000 |
| Not at all dusty | 137(10.0%) | 109(8.0%) | 85(6.2%) | 84(6.1%) | 415(30.4%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |
| **STUFFY** | | | | | | | |
| Very stuffy | 41(3.0%) | 15(1.1%) | 22(1.6%) | 37(2.7%) | 115(8.4%) | | |
| Stuffy | 136(9.9%) | 64(4.7%) | 69(5.0%) | 72(5.2%) | 341(24.9%) | | |
| Neutral | 180(13.1%) | 110(8.0%) | 200(14.6%) | 233(17.0%) | 723(52.8%) | 100.646[a] | .000 |

| | | | | | |
|---|---|---|---|---|---|
| Fresh | 41(3.0%) | 28(2.0%) | 73(5.3%) | 13(0.9%) | 155(11.3%) |
| Very Fresh | 12(0.9%) | 9(0.7%) | 16(1.2%) | 1(0.1%) | 38(2.8%) |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** |

**Source:** Researcher's Field Survey, 2024

In terms of dust, results in Table 4.11b revealed that, 34.7% perceived the air entering the room to be slightly dusty, 30.4% not dusty at all, 20.5% somewhat dusty, 12.8% moderately dusty and 2% extremely dusty. One-third (10%) out 30.4% of respondents who perceived the air entering the room as not dusty at all are from University of Ibadan. Again, the percentage of respondents who perceived the room air quality as slightly dusty is higher in Lead City University (10.2%) and Ajayi Crowther University (10.5%) when compared to University of Ibadan (7.3%) and Abiola Ajimobi Technical University (6.7%). 1.2% out of 2% of respondents that rated the room air quality as extremely dusty are from University of Ibadan. Furthermore, indoor air quality in terms of how a room is stuffy was examined. Results indicated that 24.9% of respondents perceived indoor air quality to be stuffy, 8.4% very stuffy, 11.3% fresh, and 2.8% very fresh. More than half (52.8%) of the respondents remained neutral on assessment of indoor air quality based on the level of stuffy.

Summarily, the results indicated that higher percentages of respondents are either sometimes (21.4%), often (32.7%) or always (33.4%) opened windows of their hostel rooms across the four institutions. In this regard, the attitude of window openings by the students is corresponding to the previous researches that, for an ideal comfortable surroundings, window opening plays an essential role in achieving better indoor air quality. This could be achieved through free flow of ventilation especially cross ventilation to permit stale air escapes through the openings[28, 29]. Likewise, the respondents declared that the indoor air quality of the hostel rooms across the four institutions under study is slightly smelly (34.7%); slightly dusty (34.7%) and either very stuffy or stuffy (33.3%). The smelly, dusty and stuffy conditions of indoor air quality in hostel rooms are as a result of indoor contaminants, emission of building & furnishings materials, overcrowding of the hostel room, outdoor pollutants and low ventilation rate. This finding supports the argument that, poor indoor air quality is a result of indoor pollutants entering a building through infiltrations, natural and mechanical ventilation systems, and combustion sources (such as burning wood, coal, and fuel; tobacco products; and candles). Indoor pollutants can also be originated inside the building from emissions of building materials and furnishings; central heating and cooling systems; humidification devices; moisture processes; electronic equipment; pet care products; as well as from building occupant's behaviours (i.e. smoking, painting, etc.)[30]. Furthermore, this fact aligned with past research that the frequent opening of doors & windows allowed contaminants like outdoor air-dust, smoke, and insects to enter the rooms, thus lessened and negatively influenced the occupants' overall wellbeing[31].



#### 4.1.3.2.3 Level of Satisfaction with Acoustics/Noise in the Hostel Rooms

Acoustics/noise is the third IEQ component examined in the study. The results in Table 4.12 indicated that 40.7% remained neutral, while 42% are dissatisfied with the level of noise in their hostel room while 17.4% are satisfied with level of noise in their hostel room. The percentage of respondents who are very satisfied with the level of noise in their hostel room is higher in Abiola Ajimobi Technical University (2%) compared to Lead City University (1.5%), and University of Ibadan (1.3%). In terms of percentage of respondents that are very dissatisfied with level of noise in hostel room, the breakdown of results in Table 4.12 showed that University of Ibadan (5.8%) recorded higher compared to Abiola Ajimobi Technical University (4.2%), Ajayi Crowther (4.1%), and Lead City University (3.5%). Chi-square statistics further reveal that significant differences exist in the respondents level of satisfaction with noise in their hostel room ($X= 138.261$, $p<0.05$).

**Table 4.12:** Acoustics/Noise in Hostel Room

| Items | University of Ibadan | Abiola Ajimobi Technical University, Ibadan | Lead city University, Ibadan | Ajayi Crowther University, Oyo | Total | Chi-Square (X) | Sig |
|---|---|---|---|---|---|---|---|
| | **Name of the Institution** | | | | | | |
| | **F (%)** | **F (%)** | **F (%)** | **F (%)** | **F (%)** | | |
| | **LEVEL OF SATISFACTION WITH SOUND/NOISE IN HOSTEL** | | | | | | |
| Very dissatisfied | 80(5.8%) | 58(4.2%) | 48(3.5%) | 56(4.1%) | 242(17.7%) | | |
| Slightly dissatisfied | 113(8.2%) | 5(0.4%) | 99(7.2%) | 116(8.5%) | 333(24.3%) | | |
| Neutral | 135(9.8%) | 100(7.3%) | 165(12.0%) | 158(11.5%) | 558(40.7%) | 138.261 | .000 |
| Slightly-satisfied | 64(4.7%) | 35(2.6%) | 48(3.5%) | 26(1.9%) | 173(12.6%) | | |
| Very satisfied | 18(1.3%) | 28(2.0%) | 20(1.5%) | 0(0.0%) | 66(4.8%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |
| | **QUALITY OF SPEECH COMMUNICATION BETWEEN RESPONDENT AND ROOM-MATES** | | | | | | |
| Very dissatisfied | 30(2.2%) | 18(1.3%) | 13(0.9%) | 30(2.2%) | 91(6.6%) | | |
| Slightly dissatisfied | 38(2.8%) | 16(1.2%) | 42(3.1%) | 13(0.9%) | 109(7.9%) | | |
| Neutral | 151(11.0%) | 68(5.0%) | 164(12.0%) | 132(9.6%) | 515(37.6%) | 58.121 | .000 |
| Slightly-satisfied | 118(8.6%) | 46(3.4%) | 74(5.4%) | 103(7.5%) | 341(24.9%) | | |
| Very satisfied | 73(5.3%) | 78(5.7%) | 87(6.3%) | 78(5.7%) | 316(23.0%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |

| | | | | | |
|---|---|---|---|---|---|
| **EFFECT OF NOISE ON ABILITY TO CONCENTRATE IN THE HOSTEL** | | | | | |
| Yes | 189(13.8%) | 104(7.6%) | 143(10.4%) | 112(8.2%) | 548(39.9%) |
| No | 138(10.1%) | 93(6.8%) | 145(10.6%) | 113(8.2%) | 489(35.6%) |
| Neutral | 83(6.0%) | 29(2.1%) | 92(6.7%) | 131(9.5%) | 335(24.4%) |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** |

**Source:** Researcher's Field Survey, 2024

On interpersonal communication in the hostel rooms, results in Table 4.1, indicated that 47.9% of respondents stated that they are satisfied, while 14.5% and 37.6% are very dissatisfied and neutral respectively. The  percentage of respondents that are satisfied with the quality of interpersonal communication in their room is higher in University of Ibadan (8.6%) compared to other institutions (Abiola Ajimobi Technical University 3.4%, Lead City University 5.4%, Ajayi Crowther University 7.5%). On the effect of noise in hostel room, results revealed that 39.9% of respondents across the four institutions, agreed that it has an effect on their ability to concentrate, while 35.5% stated otherwise (i.e. it has no effect) and 24.4% neutral.

Nevertheless, following the results of level of sound/noise in the hostel rooms across all institution under study, it is revealed that more respondents (42%) showed their dissatisfaction towards noise/sound in the hostel rooms. The result is in compliance with the earlier studies that, when the level of noise in the hostel rooms is beyond the speculated limit with the background noise in occupied spaces as prescribed by Acoustical Society of America, it creates discomfort and dissatisfaction to the occupants in the building indoor[32, 33, 34]. However, the outcome indicated that students are extremely pleased (47.9%) with the interpersonal communication that takes place in their rooms. The degree of satisfaction with interpersonal communication in the hostel could be attributed to the level of interaction among the students during group discussions and assignments. Therefore, the result opposed the assertion in the previous study that, indoor noisy condition is negatively affecting building occupants' communication and interaction skills, thus impacting their satisfaction, comfort, wellbeing and performance[35].

Also, the findings revealed that, the higher percentage of respondents stated that the noise interferes with their ability to concentrate whether during reading or sleeping in the hostel rooms. This suggests that poor concentration can lead to difficulties with reading, learning, and sleeping, as well as mental health issues from prolonged exposure, all of which can affect students' wellbeing, satisfaction, comfort, productivity and overall health. The outcome was consistent with earlier research showing that residing in noisy environments can cause concentration impairment and other mental health issues in occupants[36]. Additionally, reading, teaching, and learning are all negatively impacted by a poor acoustic/noise environment, which has an impact on occupants' satisfaction and wellbeing[33, 37].

#### 4.1.3.2.4 Level of Satisfaction with Lighting/Visual Conditions

Visual /lighting in the hostel room is also a component of IEQ attribute examined in this objective. One-way ANOVA test was performed to examine how respondents across the four institutions assessed the visual/lighting in their hostel room. Results in Table 4.13a, revealed that there is a significant difference in the level of satisfaction with visual reflection and glare in hostel room across the institutions ($F = 8.441$, $p<0.05$). The Post-hoc multiple comparison test further revealed that Abiola Ajimobi Technical University (mean 3.2) and Lead City University (3.0) scored higher mean than University of Ibadan (2.9) and Ajayi Crowther University (2.8%). What this result suggests in practical terms is that, respondents from the former were satisfied with visual reflection and glare in their hostel room, while the latter were dissatisfied.

Again, results in Table 4.13a revealed that significant difference exists in the level of respondents satisfaction with electrical/artificial lighting in the hostel room ($F= 5.331$, $p<0.05$). Post-hoc results again showed that respondents from Abiola Ajimobi Technical

University (3.08) and Lead City University (3.16) scored higher mean than those from University of Ibadan (2.95) and Ajayi Crowther University (2.85), which suggests that former were satisfied with electrical lighting in their hostel while the latter were dissatisfied.

Natural light is the most common source of energy available to occupants. It enhances visual comfort and other activities. Respondents were asked to rate how often they make use of natural light in their hostel room. Results in Table 4.13a showed that there is significant variation in the level of natural light utilization in hostel room across the four institutions ($F = 5.791$, $p<0.05$). The Post-hoc test showed that respondents from University of Ibadan recorded lower mean (2.2), compared to the other three institutions (Abiola Ajimobi Technical University (2.4), Lead City University (2.4), Ajayi Crowther University (2.5). Meaning that respondents from these three universities tended to use natural light in their hostel room more than those from University of Ibadan.

Respondents were further asked to rate how often they need to adjust or control the natural lighting in their hostel room. Results indicated that the respondents from University of Ibadan, Lead City University and Abiola Ajimobi Technical University with mean scores less than 3.0 rarely adjust or control the natural light in their hostel room while respondents from Ajayi Crowther with mean score of 3.5, sometimes adjust or control natural light in their hostel room. The one-way ANOVA results further revealed that there is significant difference in the level of control of natural light in the hostel room across the institutions ($F = 26.340$, $p<0.05$).

**Table 4.13a:** Visual/Lighting Conditions in Hostel Rooms

| Items | Institution | Mean | Std. Deviation | Std. Error | F | Sig | Tukey B Post-hoc homogenous subsets | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | *Subset1* | *Subset 2* |
| On average, how satisfied are you visually with reflection and glare in your hostel room? | University of Ibadan | 2.93 | 1.078 | .053 | 8.441 | .000 | 2.93 | |
| | Abiola Ajimobi Technical University, Ibadan | 3.18 | 1.249 | .083 | | | | 3.18 |
| | Lead city University, Ibadan | 3.04 | .995 | .051 | | | | 3.04 |
| | Ajayi Crowther University, Oyo | 2.77 | .804 | .043 | | | 2.77 | |
| | **Total** | **2.96** | **1.031** | **.028** | | | | |
| How satisfied are you with the electrical/artificial lighting conditions in the hostel? | University of Ibadan | 2.95 | 1.089 | .054 | 5.331 | .001 | | 2.95 |
| | Abiola Ajimobi Technical University, Ibadan | 3.08 | 1.369 | .091 | | | 3.08 | |
| | Lead city University, Ibadan | 3.16 | 1.058 | .054 | | | 3.16 | |
| | Ajayi Crowther University, Oyo | 2.85 | 1.063 | .057 | | | | 2.85 |
| | **Total** | **3.00** | **1.131** | **.031** | | | | |
| How often do you use natural lighting in your hostel room? | University of Ibadan | 2.20 | 1.037 | .051 | 5.791 | .001 | 2.20 | |
| | Abiola Ajimobi Technical University, Ibadan | 2.40 | .860 | .057 | | | | 2.40 |
| | Lead city University, Ibadan | 2.39 | .967 | .050 | | | | 2.39 |
| | Ajayi Crowther University, Oyo | 2.47 | .820 | .043 | | | | 2.47 |
| | **Total** | **2.35** | **.941** | **.025** | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| How often do you need to control or adjust natural lighting by yourself in the hostel room? | University of Ibadan | 2.90 | 1.144 | .057 | 26.34 | .000 | 2.90 | |
| | Abiola Ajimobi Technical University, Ibadan | 2.94 | 1.168 | .078 | | | 2.94 | |
| | Lead city University, Ibadan | 2.93 | 1.016 | .052 | | | 2.93 | |
| | Ajayi Crowther University, Oyo | 3.49 | .890 | .047 | | | | 3.49 |
| | **Total** | **3.07** | **1.081** | **.029** | | | | |
| Please, rate the level of artificial lighting sufficiency for reading ability in your room | University of Ibadan | 3.14 | 1.147 | .057 | 3.938 | .008 | 3.14 | |
| | Abiola Ajimobi Technical University, Ibadan | 3.14 | 1.501 | .103 | | | 3.14 | |
| | Lead city University, Ibadan | 3.31 | 1.048 | .054 | | | 3.31 | |
| | Ajayi Crowther University, Oyo | 3.38 | .762 | .040 | | | | 3.38 |
| | **Total** | **3.25** | **1.103** | **.030** | | | | |

**Source:** Researcher's Field Survey, 2024

Again, the level of artificial light sufficiency in the hostel room was examined. ANOVA results in Table 4.13a revealed that significant differences exist in the respondents perception on level of artificial light sufficiency in their hostel room ($F= 3.938$, $p<0.05$). Based on the Post-hoc results, University of Ibadan, Abiola Ajimobi Technical University and Lead City University are in group 1, which suggests that respondents from these institutions are similar in their perception of level of artificial light sufficiency in hostel room. On the other hand, respondents from Ajayi Crowther University are in group 2. Going by mean scores obtained in Table 4.13a for each institution, it could be said that respondents from Ajayi Crowther University rated the level of artificial light sufficiency higher compared to the other three institutions.

**Table 4.13b:** Daily Average Electrical/Artificial Light Used in Hostel Room

| Items | Name of the Institution | | | | Total | Chi-Square (X) | Sig |
|---|---|---|---|---|---|---|---|
| | University of Ibadan | Abiola Ajimobi Technical University, Ibadan | Lead city University, Ibadan | Ajayi Crowther University, Oyo | | | |
| | F (%) | F (%) | F (%) | F (%) | F (%) | | |
| | **Does the artificial lighting of your room affect your ability to study at night** | | | | | | |
| No | 161(11.8%) | 83(6.1%) | 89(6.5%) | 36(2.6%) | 369(26.9%) | | |
| Yes | 186(13.6%) | 142(10.3%) | 204(14.9%) | 272(19.8%) | 804(58.6%) | 154.201 | .000 |
| Neutral | 63(4.6%) | 1(0.1%) | 87(6.3%) | 48(3.5%) | 199(14.5%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |
| | **Daily average of electrical/artificial lighting used in room after daily academic activities** | | | | | | |
| 1-2 hours | 17(1.2%) | 6(0.4%) | 22(1.6%) | 12(0.9%) | 57(4.2%) | | |
| 3-4hours | 73(5.3%) | 24(1.7%) | 109(7.9%) | 113(8.2%) | 319(23.3%) | | |
| 5-6hours | 121(8.8%) | 83(6.1%) | 136(9.9%) | 125(9.1%) | 465(33.9%) | 91.081 | .000 |
| 7-8hours | 103(7.5%) | 47(3.4%) | 66(4.8%) | 69(5.0%) | 285(20.8%) | | |
| More than 8 hours | 96(7.0%) | 66(4.8%) | 47(3.4%) | 37(2.7%) | 246(18.0%) | | |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** | | |

**Source:** Researcher's Field Survey, 2024

Likewise, the results in Table 4.13b revealed that more than half (58.6%) of the respondents across the four institutions said yes, that artificial lighting in their hostel room affect their ability to study at night, while 26.9% said no but 14.5% remained neutral in their answer to this question. Among the institutions, the percentage of respondents from Ajayi Crowther University and Lead City University who said yes, that artificial lighting affect their ability to study at night is higher compared to other institutions. The reason for this is not farfetched, among the four institutions; two are government owned, while two are privately owned. One of the primary challenges facing public universities (government owned) is erratic grid electricity supply; however, most private institutions have made alternative arrangement to address the issue of erratic electricity supply from grid through the provision of generators that work round the clock to generate electricity in the hostel spaces.

In terms of daily average number of hours respondents use electrical/artificial light in their hostel rooms for academic activities, results in Table 4.13b indicated that about 33.9% use between 5-6 hours, 23.3% 3-4 hours, 20.8% 7-8 hours, and 18% more than 8 hours. The breakdown of results showed that the percentage of respondents from Lead City University (9.9%) and Ajayi Crowther University (9.1%), who use artificial light in hostel room for academic activities between 5-6 hours daily is higher than those from University of Ibadan and Abiola Ajimobi Technical University. The Chi-square statistics revealed that significant differences exist in the average number of hours respondents across the four institutions use electrical lighting in their hostel room for academic activities ($X = 91.081$, $p<0.05$).

The result from the mean score on students' average visual satisfaction with reflection and glare in hostel rooms revealed that most of the residing students across all four sampled institutions are not fully satisfied in the hostel rooms with a significant difference in the level of satisfaction with visual reflection and glare in hostel room across the institutions. This is in compliance with former studies that, dissatisfaction with reflection and glare in the indoor can cause visual discomfort leading to a negative impact on occupants' wellbeing, causing a sensation of annoyance or pain, thereby reducing productivity[38].

Based on the satisfaction level of students with the electrical/artificial lighting conditions in the hostel room, the mean score result (3.0) showed a strong satisfaction with electrical/artificial lighting conditions by majority of the students across all sampled institutions. This implies that the hostel rooms were equipped with the appropriate artificial lighting conditions. This is in conformity with previous studies on student hostel in other region that, the occupant students preferred and satisfied with the lighting conditions in their hostels due to appropriate and adequate equipped electrical/artificial lighting dimensions[33]. This may improve building occupants' visual comfort, attitude & emotion and enhances focus[39]. It may also enhance the occupants' morale, satisfaction, wellbeing, work quality and productivity[35].

On the issue of degree of using/adopting natural light in the hostel rooms, the result showed a lower total mean score of 2.35, as responded by the students across the sampled institutions. This therefore implies that, the students are tended to use natural light but rarely than artificial lighting in their hostel room. It is thereby concurred with previous research that, natural daylighting provides better visual performance, a key concept to satisfaction and wellbeing[40]. It is also aligned with other study that, the use of natural lighting influences wellbeing, satisfaction and learning outcomes of the users[41].

The study on the frequency of needs to control or adjust natural lighting by the students in the hostel rooms revealed a total mean score of 3.07, infers that the occupants sometimes adjust or control natural light in their hostel room. However, some students rarely control or adjust natural light in their hostel room as indicated by mean scores of less than 3.0 in some institutions. The control or adjustment of natural daylighting in the hostel rooms is in conformity with another study in other region that, users who can easily adjust natural lighting are more comfortable and satisfactory than other users, who are unable to control natural lighting due to the fact that the indoor illuminance level is in inadequate control in relation to the outside lighting level[42].

In rating the level of artificial lighting sufficiency for reading ability in hostel room, it was found from the result of mean score that all the students in the hostel rooms across the sampled institutions claimed that, the level of artificial lighting in the hostel is sufficient and adequate for reading ability. This therefore supports the affirmation from other study that, sufficient and adequate artificial lighting increases visual comfort, concentration to reading, happiness, hence occupants' wellbeing[43]. However, more than half (58.6%) of the respondents across the four institutions declared that their reading ability at night in their various hostel rooms is seriously being affected/tampered by artificial lighting due to not more than 5 to 6 hours average daily electrical/artificial lighting used in their room.

In summary, the satisfaction of the students with indoor environmental conditions of the hostels is relevant to Sustainable Development Goals (SDGs) 3, 4 and 11 to promote a healthier, more productive and sustainable living environment that support learning performance and overall wellbeing[11].

**4.1.4 Research Question Four:** What are the impacts of IEQ conditions on the wellbeing of students in the hostel rooms of the selected universities?

**4.1.4.1 Level of Students' Wellbeing in the Hostel Rooms**

The results in Table 4.14 indicated that, 48% of students across the four institutions in the study area agreed that sleep quality in their hostel rooms is good, while 30.6% rated sleep quality in their hostel rooms fair, 8.3% rated it very good, while 7.7% rated it poor. Furthermore, the breakdown of results revealed that among the institutions, the number of respondents who rated the level of sleep quality in their hostel as good is highest in Ajayi Crowther University (17.3%) followed by Lead City University (12.8%), University of Ibadan (10.9%) and Abiola Ajimobi Technical University (6.9%).

From the result though, the majority of the students declared that, their sleep quality (61.7.0%) are not interfered by the indoor conditions of the hostel rooms. It therefore signifies that, the existing indoor environmental conditions of the hostel rooms have little or less effect on the occupants' sleep quality in the hostel rooms. This result against a related research work that, unsatisfactory and unacceptable indoor environmental quality is significantly influences/affects quality of sleeping efficiency and satisfactions of dormitory occupants, causing long-term cognitive disturbances and declined wellbeing of the occupants[44].

Another indicator of wellbeing examined is motivation to wake-up for daily academics activities. Results (Table 4.14) revealed that less than one-quarter (25.0%) of respondents across the four institutions stated that they have high motivation to wake-up for daily academic activities while 25.7% stated otherwise (i.e. have low motivation). Among the institutions, the percentage of respondents who agreed that they have high motivation to wake-up for daily academic activities is highest for Lead City University (high =5.7%, very high =1.9%), followed by Aajyi Crowther University (high = 3.3%, very high = 2.7%), University of Ibadan (High =5.9%, very high= 0.9%), Abiola Ajimobi Technical (high = 4.5%, very high=0.1%). For those who stated that they have low motivation to wake-up daily for academic activities, results showed that the percentage of respondents from University of Ibadan is highest followed by Abiola Ajimobi Technical University, Lead City University and Ajayi Crowther University. What this result suggested therefore, is that students' wellbeing in hostel rooms in terms of level of sleep quality is higher in Ajayi Crowther and Lead University compared to others. Also motivation to wake-up for daily academic activities is higher in the two institutions when compared to others (University of Ibadan and Abiola Ajimobi Technical University).

However, the result revealed that, the majority of the respondents (49.3%) were neutral to the level of being motivated to wake-up for daily academics activities, despite having more students (25.7%) declaring that they were less motivated to wake-up for daily academics activities than those students (25%) stated otherwise (i.e. highly motivated to wake-up for daily academics activities). It is therefore revealed that, the occupant students are less motivated to wake-up for daily academics activities in the hostel rooms, though, the students are less than half of the total respondents. This finding is therefore synonymous to earlier study that, poor IEQ conditions impaired occupants' cognitive function, worsening the negative effects of low motivation on students' wellbeing[45]. It also supports the assertion that, students with low motivation are less satisfied with their learning environment and overall physical wellbeing, thus leading to low productivity[46].

In terms of the effect of the existing condition of hostel rooms on students' health, the results indicated that about 45.3% of the respondents said that the condition of the hostel rooms has no effect on their health, 31.9% remain neutral to this question while 22.8% said it has effect on their health. Furthermore, some sick buildings symptoms were examined in order to have more insight on the students' health in the hostel rooms. Though, the majority of the students declared that, their health status (45.3%) are not interfered by the indoor conditions of the hostel rooms. Though, these percentages are less than half of the investigated hostel users. It therefore implies that the existing indoor environmental conditions of the hostel rooms have little or less effects on the occupants' health status. This fact is coincided with the prior findings that unsatisfactory and unacceptable indoor environmental quality affects occupants' health conditions in the indoor as well as inversely affecting the occupants' wellbeing [47].

Furthermore, the results in Table 4.14 indicated that, percentage of respondents across the four institutions identified at least one or two symptom(s) of sick building symptoms with the highest percentage of the following: headache (17.9%), dry irritated skin (15.5%), irritated nose and throat (13.9%), fatigue (13.6%), cold hands and feet (10.7%). What could be deduced from this result is that, headache, dry irritated skin, irritated nose and throat and fatigue are sick building symptoms prevalent in the hostel rooms.

This connotes to the previous research that, the building indoor/spaces with poor indoor environmental quality is related to the emergence of sick building symptoms[48]. The finding further connotes with the prior study that the sick building syndrome is a situation in which building occupants experience, more frequently than expected, a range of common symptoms causing them to feel unwell, creating a feeling of discomfort with declined productivity which appear to be linked to the time spent in a building, with no specific identifiable illnesses. This can be grouped into five major categories: skin irritation, eye irritation, upper respiratory symptoms, lower respiratory symptoms, and general or non-specific symptoms[49].

**Table 4.14:** Students Wellbeing in Hostel Rooms

| | Name of the Institution | | | | Total |
|---|---|---|---|---|---|
| | **University of Ibadan** | **Abiola Ajimobi Technical University, Ibadan** | **Lead city University, Ibadan** | **Ajayi Crowther University, Oyo** | |
| | **F (%)** | **F (%)** | **F (%)** | **F (%)** | **F (%)** |
| | **Sleep Quality Level in the Hostel Room** | | | | |
| Poor | 25 (1.8%) | 31(2.3%) | 25(1.8%) | 25 (1.8%) | 106 (7.7%) |
| Fair | 174 (12.7%) | 50 (3.6%) | 103 (7.5%) | 93 (6.8%) | 420 (30.6%) |
| Good | 150 (10.9%) | 95 (6.9%) | 176 (12.8%) | 237 (17.3%) | 658 (48.0%) |
| Very good | 47 (3.4%) | 14 (1.0%) | 52(3.8%) | 1 (0.1%) | 114 (8.3%) |
| Excellent | 14 (1.0%) | 36 (2.6%) | 24 (1.7%) | 0 (0%) | 74 (5.4%) |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** |
| | **Motivation to wake-up for daily Academic activities every Morning** | | | | |
| Very low | 36 (2.6%) | 20(1.5%) | 33 (2.4%) | 14 (1.0%) | 103 (7.5%) |
| Low | 101(7.4%) | 67(4.9%) | 50 (3.6%) | 32 (2.3%) | 250 (18.2%) |
| Neutral | 179 (13.0%) | 76 (5.5%) | 193 (14.1%) | 228 (16.6%) | 676(49.3%) |
| High | 81 (5.9%) | 62(4.5%) | 78 (5.7%) | 45 (3.3%) | 266 (19.4%) |
| Very High | 13 (0.9%) | 1 (0.1%) | 26(1.9%) | 37 (2.7%) | 77 (5.6%) |
| **Total** | 410(29.9%) | 226(16.5%) | 380(27.7%) | 356(25.9%) | 1372(100.0%) |
| | **Existing Indoor Condition of the Room Effect on Health Status** | | | | |
| Yes | 102 (7.4%) | 113 (8.2%) | 79 (5.8%) | 19 (1.4%) | 313 (22.8%) |
| No | 219 (16.0%) | 89 (6.5%) | 198 (14.4%) | 116 (8.5%) | 622 (45.3%) |
| Neutral | 89 (6.5%) | 24 (1.7%) | 103 (7.5%) | 221 (16.1%) | 437 (31.9%) |
| **Total** | 410(29.9%) | 226(16.5%) | 380(27.7%) | 356(25.9%) | 1372(100.0%) |

| | | | | | |
|---|---|---|---|---|---|
| | | **Sick Building Symptoms frequently experienced** | | **Indoors** | |
| Headache | 72 (5.2%) | 39 (2.8%) | 74(5.4%) | 60(4.6%) | 245 (17.9%) |
| Dizziness | 34(2.5%) | 19(1.4%) | 28(2.0%) | 26(1.9%) | 107(7.8%) |
| Fatigue | 59(4.3%) | 27(2.0%) | 53(3.9%) | 47(3.4%) | 186(13.6%) |
| Dry irrigated skin | 55(4.0%) | 37(2.7%) | 65(4.7%) | 56(4.1%) | 213(15.5%) |
| Irritated nose and throat | 60(4.4%) | 33(2.4%) | 43(3.1%) | 55(4.0%) | 191(13.9%) |
| Irritated eyes | 43(3.1%) | 17(1.2%) | 27(2.0%) | 27(2.0%) | 114(8.3%) |
| Asthma | 7(0.5%) | 3(0.2%) | 4(0.3%) | 4(0.3%) | 18(1.3%) |
| Cold hands and feet | 35(2.6%) | 26(1.9%) | 43(3.1%) | 43(3.1%) | 147(10.7%) |
| Coughing | 34(2.5%) | 22(1.6%) | 35(2.6%) | 33(2.4%) | 124(9.0%) |
| Concentration difficulty | 11(0.8%) | 3(0.2%) | 8(0.6%) | 5(0.4%) | 27(2.0%) |
| **Total** | **410(29.9%)** | **226(16.5%)** | **380(27.7%)** | **356(25.9%)** | **1372(100.0%)** |

**Source:** Researcher's Field Survey, 2024

#### 4.1.4.2 Examine the effect of IEQ conditions on Students' Wellbeing in Hostel Rooms

In order to examine the effect of the IEQ conditions on Students' wellbeing in hostel rooms, regression analysis was conducted.

The equation is written as: $Y_{DC} = C + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \ldots\ldots\ldots\ldots + \beta_n D_n$

Whereby:

$Y_{DC}$ = Students' Wellbeing (level of motivation to sleep and wake-up early daily for academic activities) measured as ordinal

$D_1$ = Level of noise in hostel room (mechanical, indoor, outdoor) measured as ordinal

$D_2$ = Average visual/ lighting in hostel room (daily natural light, electrical/artificial, visual reflection and glare) measured as ordinal

$D_3$ = Air quality in hostel room (level of smell, dust, stuffy) measured as ordinal

$D_4$ = Thermal conditions (level of thermal sensations, hostel temperature, air movement, moisture/humidity) measured as ordinal

The results in Table 4.15 indicated that at 0.05 level of significance, there is significant relationship between the IEQ conditions and students' wellbeing (39.142, $p<0.05$). With a coefficient determination R value of .493, it could be said that the independent variables (IEQ conditions) accounted for about 49% variation in wellbeing of students in the hostels. The next step is to identify the contribution of each IEQ component in explaining variation in wellbeing of students in the hostel rooms. In regression analysis, the contribution of each independent variable in the model, shows the relevance or otherwise of the variable in explaining the outcome (dependent variable).

**Table 4.15:** ANOVA Result on the effect of IEQ conditions on Students' Wellbeing in Hostel Rooms

| ANOVA[a] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 118.612 | 4 | 29.653 | 39.142 | .000[b] |
| | Residual | 1035.606 | 1367 | .758 | | |
| | Total | 1154.219 | 1371 | | | |

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| **1** | **.493[a]** | **.321** | **.100** | **.870** |

**Source:** Researcher's Field Survey, 2024



The contribution of the independents variables (IEQ conditions) in explaining the outcome (wellbeing of students) is presented in details in Table 4.16. The standardized beta coefficient values (β) give an insight on the contribution of each independent variable in the regression analysis. Thus, higher standardized beta value suggests that the independent variable in question contributes more in explaining variation in the outcome compared to others. Also, the P-value guides in establishing whether or not an independent variable in the regression model has any relationship with the dependent variable (outcome). $P < 0.05$ shows that there is a significant relationship between the independent variable in question and the dependent variable (outcome). In against this backdrop, the results in Table 4.16 are interpreted. Results revealed that indoor air quality with a standardized beta coefficient ($\beta = -.194$, $p<0.05$) contributed most in the model. What this means is that, among the IEQ components, indoor air quality has the highest effect on students' wellbeing. In other words, indoor air quality which has a function of smell and dust in the air, in the hostel room has more effect on the students' wellbeing compared to other IEQ conditions. A closer look at the standardized beta value revealed that a negative relationship exists between indoor air quality and students' wellbeing, meaning that, a decrease in the level of dust and smell in the hostel room brings about improved wellbeing of students.

The next IEQ condition that contributed significantly in the regression analysis in explaining the wellbeing of students in the hostel room is visual lighting ($\beta = .106$, $p<0.05$). Visual lighting as shown by the results in Table 4.16 has a positive relationship with students' wellbeing. Visual lighting is a function of daily average hours of natural lighting in the hostel room, daily electricity lighting, visual reflection and glare in the hostel room. What this result suggested is that, the levels of natural lighting entering a room, and daily supply of artificial lighting (electricity) have some effect on the students' wellbeing. When there is regular power supply in the hostel room, students will be motivated to wake-up at night to study and engage in other academic activities.

The third IEQ condition that contributed significantly in explaining students' wellbeing is the thermal conditions of the hostel rooms ($\beta = -.073$ $p<0.05$). Thermal condition of the hostel room is a function of room temperature, air movements and moisture in the air (humidity). Again, the results show that there is a negative relationship between thermal conditions in the hostel room and students' wellbeing. This means that, a decrease in room temperature, and air moisture (humidity) enhances students' wellbeing. When the room temperate is normal, students will be able to stay indoors to study and also sleep comfortably at night. On the contrary, extreme (high) room temperature will lead to regular sweating, lack of sleep, and even lack of concentration while studying in the hostel rooms.

Lastly, results indicated that acoustic (noise in the hostel room) has little effect (insignificant) on students' wellbeing ($\beta = -.027$, $p>0.05$). What this suggests is that noise from mechanical systems (HVAC, Fan etc), indoor instruments in the hostel room and outdoor noise (from traffic, moving vehicles etc) do not have much effect on the students' wellbeing. However, a salient point from the results is that, the negative standardized beta coefficient value obtained for acoustic in the regression analysis, which is an indication of inverse (negative) relationship. Meaning that a decrease in the level of noise in the hostel room will bring about increase in students' wellbeing.

However, all these findings are synonymous with previous studies emphasized that, there is a significant effect/impact between IEQ conditions and health, productivity & wellbeing [50, 51].

**Table 4.16:** Contribution of the IEQ Components in the Regression Model

Coefficients[a]

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | **B** | **Std. Error** | **Beta** | | |
| IEQ Conditions | (Constant) | 3.711 | .085 | | 43.738 | .000 |
| | Thermal condition | -.051 | .024 | -.073 | -2.134 | .033** |
| | Indoor Air Quality | -.165 | .030 | -.194 | -5.533 | .000** |
| | Acoustic/Noise | -.022 | .025 | -.027 | -.864 | .388 |
| | Visual/Lighting | -.084 | .025 | .106 | -3.417 | .001** |

Note: Statistics is significant at 0.05**

**Source:** Researcher's Field Survey, 2024

Finally, the impact of IEQ conditions on students' wellbeing in hostel rooms is relevant to Sustainable Development Goals (SDGs) 3 and 4 to promote students' wellbeing, health, sustainable living environment and learning success[11].

## 4.2 Validation of Conceptual Framework of the Study

The conceptual framework presented in chapter two of this study indicated four key components (thermal, indoor air quality, noise/acoustic and visual lighting) of indoor environmental quality (IEQ) that influence occupants' wellbeing and productivity in building indoors. The perception of these four key components were investigated in the research, inclusive their influences on the occupant-students' wellbeing. These four components together with compass orientations and physical measurement of the hostel rooms' layout formed the background for data collection and analysis.

This study revealed the compass orientation of the hostel buildings and physical dimensions of the hostel rooms' layout (physical measurements) which comprised of the floor area of the space, the type, number & percentage area of openings etc. It further explained the adequacy of IEQ components of thermal comfort, IAQ, lighting & acoustic and investigated the satisfaction levels with thermal, IAQ, lighting/visual and acoustic conditions in the hostels. The study therefore confirmed that, there is a significant influence between these factors and students' wellbeing.

Further key issues investigated in this study were to examine level of students' wellbeing in the hostel rooms and thus examining the impacts of IEQ components on the level of students' wellbeing. Attempt has been made to achieve this goal by considering the perception of students toward their preferences to thermal condition, indoor air quality (IAQ), visual/lighting comfort and noise/acoustic comfort, in the hostel indoors. As regard to thermal condition of the hostel room, the analysis of the survey data identified thermal sensation, thermal preferences, and sensations of air movement and humidity as indicators. It was shown that, the indoor thermal condition of the hostel room is unsatisfactory and uncomfortable and extremely influencing the overall wellbeing of the students.

As well, for the survey analysis of indoor air quality (IAQ) in the room, the study identified the frequency of window openings, level of smell in hostel room, degree of dust entering the room and level of stuffiness in the hostel room. The result confirmed that, the indoor air quality (IAQ) condition of the hostel rooms is poor and contaminated as a result of low ventilation rate, and indoor & outdoor contaminants. It is further revealed that, the indoor air quality (IAQ) of the hostel room is significantly influencing the health and wellbeing of the occupants. All the same, the survey analysis of noise/acoustic of the hostels identified level of noise/sound, level of speech communication and sources of noise in the hostel as indicator. It was revealed that, the noise in the hostel is neither comfortable nor satisfactory, thereby having strong significant effects on students' wellbeing and productivity.

Finally, the indicators explaining the visual/lighting perception of students in the survey analysis of this study are the level of satisfaction with reflection & glare, level of satisfaction with natural and artificial lightings, frequency of controlling natural and artificial lightings, period of artificial lighting usage and level of sufficiency of natural and artificial lightings, in the hostels. The finding thus signified that, the visual/lighting condition in the hostel rooms has a strong significant impact on the wellbeing of the students residing in the hostels. As a result, using the result of this research, a validated conceptual framework for evaluating the effects of indoor environmental quality (IEQ) on the wellbeing of the students in the hostel rooms is presented in figure 4.5 below

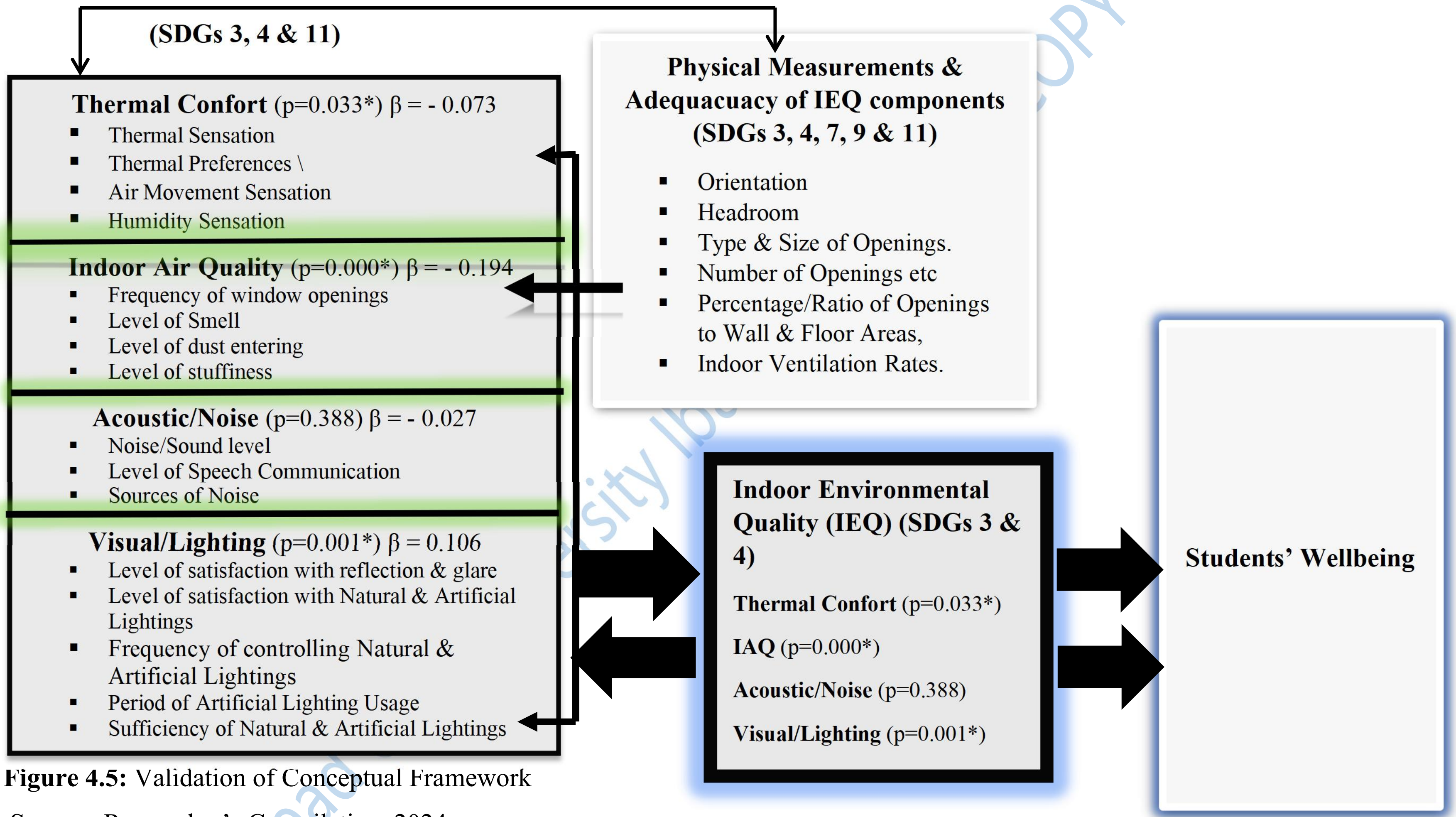



**Figure 4.5:** Validation of Conceptual Framework

**Source:** Researcher's Compilation, 2024

## Endnotes

[1]B.S. Matusiak & I. Knez, "*Impact of Building Geometry on Daylighting in Office Spaces,"* **Journal of Building Engineering,** 9, 2017: 111-119.

[2]J. Kim, J. Lee & B. Kim, "*Thermal Performance of I-Shaped Buildings: A Case Study*," **Energy and Buildings,** 151, 2017: 311-319

[3]J. Lee, Y. Lee & B. Kim, *"Impact of Building Height on Daylighting in Office Spaces,"* **Journal of Building Engineering,** 20, 2018: 111-118.

[4]J. Kang & Y. Zang, *"Noise Reduction Performance of High-rise Buildings,"* **Applied Acoustics,** 146, 2019: 227-235.

[5]D. Mudarri, W.J. Fisk & S. Sunderesan, *"Indoor Humidity and Moisture in Buildings,"* **Journal of Building Engineering,** 5, 2016: 137-145.

[6]L. Lan, P. Wargocki & Z. Lian, *"Quantitative Measurement of Productivity Loss due to Thermal Discomfort in Single Banked Buildings,"* **Building and Environment,** 175, 2020: 106824.

[7]J. Gao, H. Wang & J. Liu, *"Comprehensive Assessment of Indoor Environmental Quality in High-Ceilinged Spaces,"* **Building and Environment,** 175, 2020: 106824.

[8.] J. Lee, J. Kang, A. Gagliano, J. Kim, B. Matusiak, D. Mudarri & L. Lan, *"Combined Effects of Opposite Walls on Indoor Environmental Quality,"* **Building and Environment,** 175, 2020: 106824.

[9]J. Lee, J. Kang, J. Kim & B. Matusiak, *"Effects of Window Openings on Indoor Environmental Quality: A Review,"* **Building and Environment,** 175, 2020: 106824.

[10]J. Kang, J. Lee & J. Kim, *"Impact of Window Orientation on Indoor Environmental Quality in Office Buildings,"* **Journal of Building Engineering,** 25, 2019: 100924.

[11]WHO-World Health Organization Sustainable Development Goals (SDGs) and Disability. Available online: https://social.desa.un.org/issues/disability/sustainable-development-goals-sdgs-and-disability (accessed on 25 August 2023).

[12]M. Singh, P. Kumar, R. Gupta & P. Sharma, *"Impact of Window Type on Indoor Environmental Quality and Students' Wellbeing in Hostel Rooms,"* **Journal of Building Engineering,** 29, 2020: 101934.

[13]P. Kumar, M. Singh & R. Gupta, *"Effect of Sliding Windows on Indoor Air Quality and Ventilation in Hostel Rooms,"* **Building and Environment,** 155, 2019: 106824.

[14]E.J. Mba, F.O. Okeke & U. Okoye, "*Effects of Wall Openings on Effective Natural Ventilation for Thermal Comfort in Classrooms of Primary Schools in Enugu Metropolis, Nigeria"*, **JP Journal of Heat and Mass Transfer***,* 22, 2, 2021: 269-304.

[15]J.B. Knudsen, M. Pinder, E. Jatta, M. Jawara, M.A. Yousuf & A.T. Søndergaard, "*Measuring Ventilation in Different Typologies of Rural Gambian Houses: A Pilot Experimental Study",* **Malaria Journal***,* 19, 2020: 1-11.

[16]L.T. Lawal, "*Assessment of Natural Ventilation in Multi-Storey Residential in Abuja, Nigeria"*, **Journal of Built Environment and Geological Research,** 2023.

[17]A.K. Ayinla & I.I. Adebisi, "*Investigating Indoor Ventilation in Multi-habited Houses: A Case of Ogbomoso, Nigeria",* **International Journal of Civil Engineering, Construction and Estate Management***,* 9, 3, 2021: 1-15.

[18]M. Schweiker, E. Ampatzi, M.S. Andargie, R.K. Andersen, E. Azar, V.M. Barthelmes, C. Berger, L. Bourikas, S. Carlucci, G. Chinazzo & L.P. Edappilly, "*Review of Multi-domain Approaches to Indoor Environmental Perception and Behaviour"*, **Building and Environment,** 176, 2020: 106804.

[19]D.O. Nduka, K.D. Oyeyemi, O.M. Olofinnade, A.N. Ede & C. Worgwu, "*Relationship between Indoor Environmental Quality and Sick Building Syndrome: A Case Study of Selected Student's Hostels in South-Western Nigeria",* **Cogent Social Sciences,** 7, 1, 2021:1-17.

[20]H. Njoku, O. Odugu & N. Chibuike, "*Investigation of Indoor Thermal Comfort and Air Quality in Typical Student Residences"*, Proceed-ings Paper, 3, 2021.

[21]P. Aparicio-Ruiz, E. Barbadilla-Martín, J. Guadix & J. Munuzuri, "*A Field Study on Adaptive Thermal Comfort in Spanish Primary Classrooms during Summer Season"*, **Building and Environment***,* 203, 2021: 1-14.

[22]A.S. Adegoke, C.A. Ajayi, T.T. Oladokun & T.O. Ayodele, "*A Post-Occupancy Evaluation of Students' Halls of Residence in Obafemi Awolowo University, Ile-Ife, Nigeria"*, **Property Management***,* 39, 2, 2021: 163-179.

[23]F. Abass, L.H. Ismail, I.A. Wahab, W.A. Mabrouk & H. Kabrein, "*Indoor Thermal Comfort Assessment in Office Buildings in Hot-Humid Climate"*, IOP Conference Series: Materials Science and Engineering, IOP Publishing, 2021: 12-29.

[24]J.N. Offor, "*Investigation of the Influence of Natural Ventilation on Indoor Comfort of Occupants of Public Hospital Wards within the Hot-Humid Climates"*, **Irish International Journal of Engineering and Applied Sciences**, 6, 2, 2022.

[25]N.N.S. Khamis, R. Zainal, S.S.M. Musa & N.N. Kasim, "*Adaptation of Thermal Comfort in Naturally Ventilated Students' Residential College in Tropical Climates of Malaysia"*, **International Journal of Engineering Technology Research & Management (IJETRM)***,* 5, 6, 2021:150-158.

[26]M. Bughio, T. Schuetze & W.A. Mahar, "*Comparative Analysis of Indoor Environmental Quality of Architectural Campus Buildings' Lecture Halls and its' Perception by Building Users in Karachi, Pakistan"*, **Journal of Sustainability,** 12, 2995, 2020:1-29.

[27]Z. Yang, W. Zhang, M. Qin & H. Liu, "*Comparative Study of Indoor Thermal Environment and Human Thermal Comfort in Residential Buildings among Cities, Towns, and Rural Areas in Arid Regions of China", **Energy and Buildings**, 273, 2022: 112373.

[28]A. Sharma & A. Kumar, "*Adaptive Thermal Comfort of Residential Buildings in the Composite Climatic Region of India: A Field Study*" **Architectural Engineering and Design Management**, 2023: 1-22.

[29]V.B. Joseph, "*Affect and the Workplace Built Environment,*" Doctoral Dissertation, University of Warwick, 2020.

[30]A. Kabirikopaei, *"A Data-Driven Study on the Association of Classrooms' Indoor Air Quality, Thermal Environment, and Students' Academic Performance"*, Doctoral Dissertation, The University of Nebraska-Lincoln, 2021.

[31]J. Saini, M. Dutta & G. Marques, "*A Comprehensive Review on Indoor Air Quality Monitoring Systems for Enhanced Public Health",* **Sustainable Environment Research**, 30, 1, 2020: 1-12.

[32]O.M. Ode, K.C. Okolie, F.O. Ezeokoli & D.A. Obodoh, "*An Examination of Sources of Indoor Air Contaminants in the Students' Hostel Rooms in Nnamdi Azikiwe University, Awka-Anambra State"*. **Tropical Built Environment Journal**, 9, 2, 2023.

[33]C. Van Reenen & D. Manley, "*Classroom Acoustics: Mainstreaming and Application of Standards,"* Proceedings of Meetings on Acoustics, 51, 1, 2023.

[34]Y.A.K. Al-Taee & M.K.A.M. Sulaiman, *"Indoor Environmental Comfort in Student Hostel at Malaysia's Public University: A literature Review,"* **Jurnal Kejuruteraan**, 33, 3, 2021: 487-501.

[35]G. Minelli, G.E. Puglisi & A. Astolfi, *"Acoustical Parameters for Learning in Classroom: A Review,"* **Building and Environment**, 208, 2022: 108582.

[36]H.S. Abdulaali, M.M. Hanafiah, I.M. Usman, N.U.M. Nizam & M.J. Abdulhasan, "*A Review on Green Hotel Rating Tools, Indoor Environmental Quality (IEQ) and Human Comfort*," **Int. J. Adv. Sci. Technology,** *29,*3, 2020:128-157.

[37]M. Burfoot, A. Ghaffarianhoseini, N. Naismith & A. Ghaffarianhoseini, "*The Birth of Intelligent Passive Room Acoustic Technology: A Qualitative Review,"* **Smart and Sustainable Built Environment,** 12, 1, 2023: 60-83.

[38]I. Polewczyk & M. Jarosz, *"Teachers' and Students' Assessment of the Influence of School Rooms Acoustic Treatment on their Performance and Wellbeing,"* **Archives of Acoustics**, 45, 3, 2020: 401-417.

[39]A. Kaushik, M. Arif, O.J. Ebohon, H. Arsalan, M.Q. Rana & L. Obi, *"Effect of Indoor Environmental Quality on Visual Comfort and Productivity in Office Buildings,"* **Journal of Engineering, Design and Technology**, 21, 6, 2023: 1746-1766.

[40]Z. Shen, X. Yang, C. Liu & J. Li, *"Assessment of Indoor Environmental Quality in Budget Hotels using Text-Mining Method: Case Study of Top Five Brands in China,"* **Sustainability**, 13, 8, 2021: 4490.

[41]J. Chen, H. Hu, H. Wu, Y. Jiang & C. Wang, "*Learning the Best Pooling Strategy for Visual Semantic Embedding,"* In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition, 2021:15789-15798).

[42]N. Castilla, J.L. Higuera-Trujillo & C. Llinares, *"The Effects of Illuminance on Students' Memory: A Neuroarchitecture Study,"* **Building and Environment**, 228, 2023: 109833.

[43]G. Chinazzo, J. Wienold & M.J.L.R. Andersen, *"Influence of Indoor Temperature and Daylight Illuminance on Visual Perception,"* **Lighting Research & Technology**, 52, 3, 2020: 350-370.

[44]I. Konstantzos, S.A. Sadeghi, M. Kim, J. Xiong & A. Tzempelikos, *"The Effect of Lighting Environment on Task Performance in Buildings: A Review,"* **Energy and Buildings**, 226, 2020: 110394.

[45]W. Budiawan, H. Prastawa, G.F.P. Merdeka, S.M. Ari & T. Phommachak, **"***Field Survey Analysis of $CO_2$ Concentration and its Impact on Sleep Efficiency in University Dormitory,"* IOP Conf. Series: **Earth and Environmental Science,** 1268, 2023: 012072.

[46]A. Hamed, Y. Liu, H. Wang & X. Zheng, *"The Impact of Low Motivation on Students' Wellbeing in Poor IEQ Indoor Conditions: A Systematic Review,"* **Journal of Building Engineering,** 29, 2020: 101934.

[47]Y. Liu, A. Hamed & H. Wang, *"The Effects of Low Motivation on Students' Mental Health in Poor IEQ Indoor Conditions,"* **Building and Environment,** 155, 2019: 106824.

[48]W. Budiawan, H. Prastawa, G.F.P. Merdeka, S.M. Ari & T. Phommachak, **"***Field Survey Analysis of $CO_2$ Concentration and its Impact on Sleep Efficiency in University Dormitory,"* IOP Conf. Series: **Earth and Environmental Science,** 1268, 2023: 012072.

[49]N. Suzuki, Y. Nakayama, H. Nakaoka, K. Takaguchi, K. Tsumura, M. Hanazato, T. Hayashi & C. Mori, *"Risk Factors for the Onset of Sick Building Syndrome: A Cross-Sectional Survey of Housing and Health in Japan,"* **Building and Environment,** 2021: doi: https://doi.org/10.1016/ j.buildenv.2021.107976.

[50]Z.H. MZ & S.M. Saliluddin*, "A Review of Studies Related to Sick Building Syndrome among Office Workers,"* **International Journal of Public Health and Clinical Sciences,** *6,* 2, 2019: 21-43.

[51]Y. Liu, A. Hamed & H. Wang, *"The Effects of IEQ Conditions on Students' Mental Health and Wellbeing,"* **Building and Environment,** 155, 2019: 106824.

[52]M. Singh, P. Sharma, X. Zheng, Y. Liu, H. Wang, A. Hamed, J. Kim & Y. Lee *"The Impact of IEQ Conditions on Students' Wellbeing: A Systematic Review,"* **Journal of Building Engineering,** 29, 2020: 101934.

# Chapter Five

# Conclusion

## 5.1 Summary of Findings

The thesis presented the evaluation of Indoor Environmental Quality of hostel rooms on students' wellbeing in selected universities in Oyo State, Nigeria through the determination of compass orientation of the hostel building and physical dimensions of the hostel rooms, examining the adequacies of IEQ components of thermal comfort, Indoor Air Quality, acoustic and lighting in the hostel rooms (Objective measurement) and the administration of questionnaires (subjective measurement), thereby adopting both descriptive, explorative and inferential statistical techniques. For the descriptive statistics, mean, mode, standard deviation, cross-tabulation and simple percentages were applied, while regression analysis, one-way analysis of variance (ANOVA), Chi-Square and correlation analysis were adopted for the inferential statistics. The research revealed that, the students' satisfaction with IEQ components in hostel rooms varied among the four universities in the research area and equally showed that IEQ components influence students' wellbeing.

The study revealed from the socio-economic information of the residing students that, the students' across all the four institutions under study reflected diversity in age, gender and body weight, leading to significant differences in the students' perception/responses to IEQ conditions in the hostels. Hence, the least and the most prevalent diversity in age, gender and body weight ranged from 5.6% (27 years above) to 47.2% (18-20 years) for age; 36.9% (Female) to 62.5% (Male) for gender and 0.4% (100 kg above) to 27.3% (61-70 kg) for body-weight respectively. It was further revealed that students spent more of their daytime (averagely 60%) in the hostel rooms especially at night for reading activities, assignments and sleeping to prepare for the next day activities.

The study further revealed through the analysis of the hostel buildings' orientation and physical dimensions of the hostel rooms that, all hostel halls/buildings exhibit diverse characteristics such as geometry/form; number of floor; number of loading; headroom and window number, position, orientation & type. It therefore revealed that, all these building components characteristics of all hostel halls are in one way or the other significantly influencing IEQ conditions in the indoor, thus, enhancing students' comfort, satisfaction, health, productivity and wellbeing. The study revealed further that, the hostel building of U-shaped, single-banked, adequate headroom with the openings facing North-South or Southeast-Northwest directions and window-type facilitating adequate ventilation, promotes comfort and satisfactory indoor conditions thus enhancing occupants' wellbeing. This study is aligned with Sustainable Development Goals (SDGs) 3, 4, 7, 9 and 11 for maximizing natural light, passive heating or cooling and positively impacting health & wellbeing of the students.

Furthermore, the investigation on the adequacies of IEQ components of thermal, IAQ, acoustic and lighting showed that, the rate of indoor air flow was considered adequate in all the hostel spaces in the study area, however, IEQ conditions of thermal, IAQ, lighting and acoustic/noise were inadequate, unsatisfactory and uncomfortable in most of the hostel spaces due to inadequate and falling short to recommended standards of percentages of window/wall area (30-50%) and window/floor area (20-30%) ratios. This study therefore related to Sustainable Development Goals (SDGs) 3, 7, 9 and 11 in reducing energy consumption and promoting sustainable & resilent infrastructures.

Consequently, 52.8% of respondents perceived the thermal perception in their dormitories in the morning time to be cool, 39.7% perceived it to be warm in the afternoon and 43.5% perceived it to be cool at night. Greater than half of respondents across the four institutions in the study area rated the quality of air movement/ventilation rate in their hostel room as good and desirable. In terms of moisture/humidity, 33.4% perceived their hostel indoor to be humid during morning period, 37.2% slightly dry in the afternoon and 35.9% humid at night. The result revealed that the dormitory occupants were unsatisfactory and not comfortable with the existing indoor thermal conditions of the hostel spaces. The outcomes of this study revealed that the indoor air quality condition of the hostel rooms is smelly, dusty and stuffy as a result of low ventilation rate, and indoor & outdoor contaminants. As regard to lighting in the hostel, it was found that the hostel occupants are satisfied and comfortable with the sufficiency and adequacy of both the natural and artificial lightings, though there was more dependency on artificial lighting than natural daylight. This enhances their visual comfort, concentration to reading and improves the wellbeing of the students in the hostel rooms. However, it was revealed that one-quarter (26.1%) of respondents across the four institutions stated that electrical/artificial lighting affect their ability to study at night due to an average of 5-8 hours daily usage of electrical/artificial lighting. Thus, the study is similar to Sustainable Development Goals (SDGs) 3, 4 and 11 to promote comfortable, healthy, livable and sustainable indoor environments for the enhancement of productivity and overall wellbeing of the occupants.

It was discovered from this study that, the students' wellbeing is highly affected by the uncomfortable and unsatisfactory indoor environmental conditions of the hostel rooms. This is revealed through the significant impact imposed on the students through inefficient sleeping, low motivation to wake up earlier in the next morning for the daily activities and decline in health status. Furthermore, it was shown that, the sick building symptoms mostly prevalent in the hostel rooms are headache, dry irritated skin, irritated nose and throat and fatigue, resulted from unfavorable and unsatisfactory conditions of the hostel rooms. Therefore, the students' wellbeing is highly affected in the hostel rooms. It was further noted that all IEQ components except noise are having significant impact on the students' wellbeing in the hostel rooms. Also, indoor air quality (IAQ) and acoustic/noise were rated as the highest and lowest contributors respectively to students' wellbeing among the IEQ components investigated. All of these components or variables exhibit adverse effects on sleeping quality, reading comprehension/concentration, health issues including fatigue and headaches and finally on the students' wellbeing. The result is aligned with Sustainable Development Goals (SDGs) 3 and 4 for the enhancement of heathier, productive and sustainable indoor environment.



### 5.2 Conclusion

This study contributed to the critical evaluation of IEQ components on students' wellbeing residing in hostel rooms in selected universities in Oyo State, Nigeria so as to enhance the productivity and well-being of the hostel occupants. To achieve this goal, the objectives were developed and assessed through data analysis and adopting both descriptive, explorative and inferential statistical techniques. Consequently from the objective measurement of the hostel rooms (physical measurement), it was inferred that, irrespective of the hostel design, the windows should be designed in such a way that it permits adequate ventilation into the indoor considering the adequate and proper type & number of openings, adequate ceiling height, building geometry, window orientation in north, south, south-east or north-west directions, adequate indoor rate of ventilation, sufficient window/wall area and window/floor area ratios etc in relation to indoor spaces designs. From the study also, it was ascertained that students' hostel is usually a shelter that accommodates large number of occupants in a limited area with a lot of time spent inside the buildings. The finding confirmed that at least 3-4 students are accommodated in a hostel room and spent about 6 to 14 hours mostly at night. Therefore, it is pertinent to all stakeholders to advocate good considerations for quality indoor environmental components within students' residences and not to be neglected during design conceptualization.

In the same regard, it was found that thermal condition of the hostel rooms is unsatisfactory and uncomfortable. This is due to the comfort range for thermal parameters falling below the 80% ASHRAE Standard requirement. Therefore, it was found that students residing in the most of naturally ventilated hostel buildings in Nigeria's warm-humid climate are experiencing an unfathomable degree of indoor thermal discomfort, which has a daily negative impact on the students' productivity and wellbeing. As such, thermal comfort conditions within hostel buildings should be carefully taken into account in design practices to ensure satisfactory human thermal comfort.

Likewise, the outcome indicated that, indoor air quality (IAQ) in the hostel indoor is poor, smelly, dusty and stuffy. Therefore, the design and construction of students' hostel should permit proper and adequate ventilation rate especially through a cross-ventilated window openings. This allows stale air escapes through the opposite side openings, if any. The result reported visual comfort and satisfaction to both natural and artificial lightings in the hostel rooms but complained of affecting their concentration to reading at night due to low usage of artificial lighting at daily average of 5-8 hours. This implies that the designers must primarily improvise natural daylight using proactive approaches such as appropriate building orientation, window opening locations and sizes, and the use of suitable shading designs and devices. This can be incorporated with artificial or electrical lighting that is only utilized at night so that students can read and complete any assignments they may have in the hostels and thereby improving their cognitive/mental wellbeing.

Also, it is noted that indoor air quality, visual lighting, thermal and noise are in orderly contributed to health symptoms like headache, fatigue and others which adversely/negatively contributed to students' wellbeing in hostel rooms. Therefore, providing a conducive indoor environment could be a promising means of preventing students from exposure to preventable illnesses like sick building syndrome (SBS) hence enhances the productivity and wellbeing of the students residing in the hostel rooms. However, it was confirmed from the regression analysis result that the IEQ components of indoor air quality, visual/lighting and thermal comfort are strongly significant to wellbeing of the students while acoustic/noise condition has little effect or insignificant to students' wellbeing.

Finally, the submission revealed that indoor environmental quality in the students' hall of residence is highly vital for better sleeping environment, health, productivity and wellbeing of the students. However, poor indoor environmental quality resulted to declined wellbeing, and more frequent complaints if and when accommodations are not comfortable and unsatisfactory to the students. It is thus concluded that the architects play an important role in ensuring a comfortable hostels design and planning for the users for a considerable indoor comfort and satisfaction so as to enhance the quality of sleep, health and wellbeing of the residing students in the hostels.

### 5.3 Recommendations

As a result of findings that emphasize hostel rooms' Indoor Environmental Quality (IEQ) and its effects on students' wellbeing in selected Universities in Oyo state Nigeria, the following recommendations are made:

1. To achieve the goal of improving the wellbeing, health & sleeping qualities/conditions of the hostel occupants, all stakeholders/policy makers (government, school management) concerned should consider all IEQ components identified in this study in the course of developing passive architectural design strategies.
2. Design professionals should expedite efforts in the bid of discharging their tasks to seriously consider climate-responsive design strategy at the conceptualized design stage as one of the crucial methods for promoting and enhancing occupants' productivity and well-being.

3. To permit the escapes of stale, still, stuffy and smelly indoor air quality, cross ventilation that is mostly responsible for sustaining the indoor environmental quality in naturally ventilated building is necessary. In achieving this, windows should be placed along the north and south walls, however reducing or totally avoiding windows along east and west walls. To obtain essential and good cross-ventilation in a warm and humid areas, there should be multiple openings in more than one wall, preferably opposite walls. Subsequent to the outer wall openings in double banked buildings, there must be openings in forms of windows and/or permanent ventilation in internal walls to allow free flow of indoor air. Additionally, shading devices should be installed for windows exposed to direct sunlight, and high-level window openings are crucial for generating ventilation through the stack effect and wind.

4. Lighting is an important indoor environmental components in any building. It is therefore, the responsibility of the designers to choose an appropriate lighting types and layouts with suitable dimensions to achieve an optimum lighting environment. Hence, the lighting dimensions that should be considered in any building includes the lighting level (illumination and lamination), light transmission and consistency, and glare control. However, architects need to be cautious of daylighting approaches flaws that may lead to shortcomings, causing visual discomfort, impede vision, increasing energy demands excessively, and increase interior heat gain, which can stimulate declined wellbeing.

5. In hostel design, the designers should put into considerations of the acoustic performance standards for a better reading, learning and sleeping. An effective acoustical condition can filter or block outdoor noise from penetrating the indoor ambiences.

6. It is extremely important to minimize noise and improve the acoustical conditions of the student hostel ambience. Therefore, interior design strategies such as spatial design, building shape, sound absorbing materials and strategically placement of electrical appliances like air-conditioning units should be adopted in order to manage and put noise pollution under control in the indoors.

7. It is very vital at the early design stage that the architects should embrace a proper interpretation of building orientation, geometry, number of loading, adequate headroom, window position & number etc with regard to the climate-responsive parameters so as to enhance building indoor environmental quality. These techniques including proper building orientation, proper building geometry, adequate headroom, adequate spacing between buildings, introduction of fountain between buildings for evaporative cooling, avoid high-rise hostel building, avoid double-loading design, among others.

## 5.4 Contribution to Knowledge

The research adds to the corpus of scientific knowledge in the fields of sustainable building design through the study of indoor environmental quality with regards to the built environment. The study therefore:

1. Established that, the orientation of the hostel buildings is very vital at the conceptualized design stage. Therefore, hostel buildings should be orientated along East-West direction with its openings facing N-S or SE-NW direction to avoid direct penetration of sunlight that can cause heat gain and declined wellbeing in the indoor. However, where openings can not be avoided from direct infiltration of sunlight, sun-shading devices should be adopted.
2. Contributed that, the percentages of Window-Wall Ratio (WWR) and Window-Floor Ratio (WFR) were not adequately considered for the students' hostels design to enhance comfort, satisfaction and wellbeing of the occupants. Thus, making thermal, IAQ, lighting and acoustic comforts of the hostels inadequate, uncomfortable and unsatisfactory.
3. Established that, the indoor ventilation rates should be more enhanced for the improved occupants' satisfaction, comfort, productivity and wellbeing. This can be enhanced through the design of hostel buildings with single loading on access corridors with adequate window openings in opposite walls for proper cross-ventilation.
4. Established that, the hostel occupants were neither comfortable nor satisfactory with the IEQ components (thermal, IAQ and acoustic) of the hostel rooms. Therefore, the occupants are experiencing a declined overall wellbeing in the hostel indoors.

5. Established a strong significant relationship between IEQ components (IAQ, visual/lighting and thermal) and the wellbeing of students, however, an insignificant relationship exists between students' wellbeing and sound/noise in the hostel rooms. Therefore, establishing that IEQ components are significantly affecting the students' wellbeing in the indoors.
6. The study established that, poor indoor air quality component of IEQ mostly contributed significantly to students' discomfort, dissatisfaction and poor wellbeing state in hostel buildings.
7. Established that, IEQ components of hostel rooms are having only32.1% impact level on students' wellbeing in the hostel indoors.
8. Established an affiliation to Sustainable Development Goals (SDGs) 3, 4, 7, 9 and 11 designed by the United Nations to enhance sustainable development and build a more comprehensive future globally. The finding therefore, improves health & hygiene, enhances quality of learning and promotes environmental sustainability, thus, supports students' wellbeing.



**5.5 Suggested Areas for Further Research**

There are several areas that can be assessed for further research in understanding the effects of indoor environmental quality on building residents. Some of these include:

1. Comparative assessment of indoor environmental quality (IEQ) on students' wellbeing in other public and private universities' hostels, not assessed in this study. Research can be conducted to compare and contrast between the impacts of IEQ on students' wellbeing in other public and private universities' hostels (not included in this study) in Oyo State Nigeria. This will enhance researchers have in-depth knowledge on the contributing factors endangers occupants' wellbeing

and productivity in University's hostels. It will also pinpoint on the best climate-responsive hostel designs in Nigerian universities.

2. The findings revealed that IEQ components are significant to students' wellbeing and there exists only 32.1% impact/influence level. Therefore, IEQ variables other than the ones (thermal, Indoor Air Quality, Lighting and Acoustic) investigated in this study that may influence the students' wellbeing in the hostels should be researched. This is to analyze the impacts of different variables on students' wellbeing in the hostels.
3. The use of objective measurement, based on experiments, to determine the impacts of IEQ components on occupants'/users'wellbeing and productivity in offices, domestic homes, hostels etc.
4. The assessment of window orientation and design in enhancing occupants' productivity and wellbeing in dwelling homes, offices and educational buildings.
5. Assessment of indoor environmental quality (IEQ) components on occupants' health and sleeping efficiency in selected universities' hostels. Researches can be done to confirm the effects of IEQ components on health and sleeping qualities of the students in the hostel indoors. This will facilitate in-depth knowledge to the researchers about the association between efficient sleeping, productivity and wellbeing.
6. Assessment of Visual Lighting and its effect on students' health and productivity in University Dormitory. The study can be done to evaluate the impacts of visual lighting on occupants comfort, health, satisfaction and productivity in the hostels. This will enhance thorough knowledge to the prospective researchers/lighting designers to decide appropriate lighting types and layouts with suitable

dimensions to achieve an optimum lighting environment so as to cater for all possible functions at all diverse levels in improving psychological benefits.

7. The impacts of Noise pollution on occupants' wellbeing in domestic homes, offices and other academic buildings/offices. Research can be conducted to explore noise conditions effects on the residents of domestic homes, staff offices etc as the unfavourable noise condition endangers concentration, sleeping conditions, health, productivity and wellbeing in the buildings. This will expedite the knowledge to research and acquire learning and understanding about the different types of acoustics that can be implemented in the indoors based on the degrees of existing noise pollutions in the homes, offices etc
8. Indoor Air Quality (IAQ) assessment on occupants' productivity. Research can be conducted on the causes and effects of IAQ on occupants comfort and health with its relationship to productivity in the indoors. This will give insight to the prospective researchers on the dangerous/detrimental effects of IAQ to the occupants'/users'wellbeing, health and productivity to provide adequate openings for the free air flows into the buildings at the conceptual stage by the designers

In conclusion, these are just few areas for further researches in architectural climatic/scientific studies for achieving sustainable quality of indoor ambiences in enhancing or improving occupants' comfort, satisfaction, productivity and wellbeing in the building interiors. It is therefore pertinent to explore these and other areas to develop effective and sustainable climate-responsive techniques that can assist reduce the impacts of unfavourable and unsatisfactory indoor environmental quality parameters/components.

## Bibliography

### E-Book


Cattaneo, A., Spinazze, A. & Cavallo, D.M. *"Indoor Air Quality in Offices. In Handbook of Indoor Air Quality,"* Singapore: Springer Nature Singapore, 2022: 1935-1960.

Coronado, M.C., Feinberg, S., Fretz, M., Kwok, A., Gotlin, A., Greenheck, R., Lee, J., Pfeifer, N., Seely, J., Steeves, N. & Van Den Wymelenberg, K. "*The Impact of School Facilities on Student Learning and Engagement",* Eugene, Oregon: University of Oregon, 2021.

Dooris, M., Kokko, S. & de Leeuw, E. "*Evolution of the Settings-Based Approach, "In Handbook of Settings Based Health Promotion,"* Cham: Springer International Publishing, 2022, 3-22.

Farr, C. "*Indoor Air Quality: Causes, Controls and Consequences"*, United Kingdom: Lancaster University, 2021.

Fellows, R.F. & Liu, A.M. "*Research Methods for Construction",* United Kingdom: John Wiley & Sons, 2021: 88-120.

Harcarova, K., Vilcekova, S. & Balintova, M. "*Building Materials as Potential Emission Sources of VOC in the Indoor Environment of Buildings: In Key Engineering Materials",* Trans Tech Publications Ltd, 2020: 74-80.

Ivanov, D. "*Modeling Supply Chain Resilience. In Introduction to Supply Chain Resilience: Management, Modelling, Technology"*, Cham: Springer International Publishing, 2021: 63-92.

Leavy, P. *"Research Design: Quantitative, Qualitative, Mixed Methods, Arts-Based, and Community-Based Participatory Research Approaches",* New York: Guilford Publications, 2022: 87-116.

Mulholland, M.M., Webb, S.J.N. & Schapiro, S.J. *"Animal Models for Human Behaviour: In Handbook of Laboratory Animal Science,"* CRC Press, 2021: 633-648.

Munonye, C.C. *"Thermal Comfort Assessment of Primary School Children in a Warm and Humid Climate: A Case Study of Imo State, Nigeria"*, United Kingdom: University of Salford, 2020.

Porras-Salazar, J.A., Schiavon, S. & Tham, K.W. *"Effects of IAQ on Office Work Performance. In Handbook of Indoor Air Quality,"* Singapore: Springer Nature Singapore, 2022: 1-27.

Rector, J., Burns, V.E., Bosch, J.A. & Anane, L. *"Immune Responses to Stress: In Encyclopedia of Behavioral Medicine",* Cham: Springer International Publishing, 2020: 1145-1149.

Wolska, A., Sawicki, D. & Tafil-Klawe, M. "*Visual and Non-visual Effects of Light: Working Environment and Well-Being*," CRC Press, 2020.

**Journal**

Abass, F., Ismail, L.H., Wahab, I.A., Mabrouk, W.A. & Kabrein, H. *"Indoor Thermal Comfort Assessment in Office Buildings in Hot-Humid Climate,"* In IOP Conference Series: **Materials Science and Engineering**, 2021: 12-29.

Abdulaali, H.S. Hanafiah, M.M., Usman, I.M., Nizam, N.U.M. & Abdulhasan, M.J. "*A Review on Green Hotel Rating Tools, Indoor Environmental Quality (IEQ) and Human Comfort,"* **International Journal Advancement Science Technology**, 29, 3, 2020: 128-157.

Abdulaali, H.S., Usman, I., Hanafiah, M., Abdulhasan, M., Hamzah, M. Thomas, F., Kain, T. & Monica, G.B. Nazal, A. *"Impact of Poor Indoor Environmental Quality (IEQ) to Inhabitants' Health, Wellbeing and Satisfaction,"* **International Journal of Advanced Science and Technology,** 29, 3, 2020: 1-14.

Ab Razak, W.M.W., Baharom, S.A.S., Abdullah, Z., Hamdan, H., Abd Aziz, N.U. & Anuar, A.I.M. "*Academic Performance of University Students: A Case in a Higher Learning Institution*," **KnE Social Sciences,** 2019: 1294-1304.

Adaji, M.U., Adekunle, T.O. & Watkins, R. *"Overheating and Passive Cooling Strategies in Low-Income Residential Buildings in Abuja, Nigeria*, In Routledge Handbook of Resilient Thermal Comfort," **Routledge**, 2022: 159-174.

Adegoke, A.S., Ajayi, C.A., Oladokun, T.T. & Ayodele, T.O. "*A Post-Occupancy Evaluation of Students' Halls of Residence in Obafemi Awolowo University, Ile-Ife, Nigeria,"* **Property Management**, 39, 2, 2021: 163-179.

Aderonke, R.A. *"Influence of Socio-Economic Factors on Students' Academic Performance in Business Education, Kwara State University."* **KWASU International Journal of Education (KIJE**), 5, 1, 2022: 177-187.

Aderonmu, P., Adesipo, A., Erebor, E., Adeniji, A. & Ediae, O. "*Assessment of Daylighting Designs in the Selected Museums of South-West Nigeria: A Focus on the Integrated Relevant Energy Efficiency Features,"* In IOP Conference Series: **Materials Science and Engineering,** 640, 1, 2019: 012034.

Adewale, B., Jegede, F., Okubote, F. & Olagbadegun, M. *"Impact of Classroom Environments' on the Academic Performance of Architecture Students in Covenant University*," In IOP Conference Series: **Earth and Environmental Science,** 665, 1, 2021: 012017.

Adil, M. & Parveen, A. *"Academic Stress among Intermediate Students in Relation to Selected Demographic Factors,"* **International Journal of Applied Research,** 8, 5, 2022: 315-319.

Afolabi, A.O., Arome, A. & Akinbo, F.T. "*Empirical Study on Sick Building Syndrome from Indoor Pollution in Nigeria,"* **Open Access Macedonian Journal of Medical Sciences***,* 8, E, 2020: 395-404.

Aginako, Z., Peña-Lang, M.B., Bedialauneta, M.T. & Guraya, T. *"Analysis of the Validity and Reliability of a Questionnaire to Measure Students' Perception Of Inclusion Of Sustainability In Engineering Degrees,"* **International Journal of Sustainability in Higher Education**, 22, 6, 2021: 1402-1420.

Ahmed, I. & Ishtiaq, S. *"Reliability and Validity: Importance in Medical Research",* **Methods***,* 12, 1, 2021: 2401-2406.

Ailshire, J. & Walsemann, K.M. *"Education Differences in the Adverse Impact of PM 2.5 on Incident Cognitive Impairment among US Older Adults,"* **Journal of Alzheimer's Disease***,* 79, 2, 2021: 615-625.

Akanmu, W.P., Nunayon, S.S. & Eboson, U.C. *"Indoor Environmental Quality (IEQ) Assessment of Nigerian University Libraries: A Pilot Study,"* **Energy and Built Environment***,* 2, 3, 2021: 302–314. https://doi.org/10. 1016/j.enbenv.2020.07.004

Akova, İ., Kiliç, E., Sumer, H. & Keklikçi, T. "*Prevalence of Sick Building Syndrome in Hospital Staff and Its Relationship with Indoor Environmental Quality*," **International Journal of Environmental Health Research,** 32, 6, 2022: 1204-1219.

Alam, M.K. "*A Systematic Qualitative Case Study: Questions, Data Collection, Nvivo Analysis and Saturation,*" **Qualitative Research in Organizations and Management: An International Journal,** 16, 1, 2021: 1-31.

Al-Kayiem, H.H., Mohammed, M.N., Kelly, K., Riyadi, T.W. & Effendy, M. *"Experimental Assessment and Development of Thermal Comfort Model for Implication in Tropical Climate,"* **International Journal of Computational Methods and Experimental Measurements***,* 11, 1, 2023: 35-43.

Al-Taee, Y.A.K. & Sulaiman, M.K.A.M. *"Indoor Environmental Comfort in Student Hostel at Malaysia's Public University: A literature Review,"* **Jurnal Kejuruteraan,** 33, 3, 2021: 487-501.

Altomonte, S., Allen, J., Bluyssen, P.M., Brager, G., Heschong, L., Loder, A., Schiavon, S., Veitch, J.A., Wang, L. & Wargocki, P. "*Ten Questions Concerning Well-Being in the Built Environment*," **Building and Environment***,* 180, 2020: 106949.

Altug, H., Fuks, K.B., Hüls, A., Mayer, A.K., Tham, R., Krutmann, J. & Schikowski, T. *"Air Pollution is Associated with Depressive Symptoms in Elderly Women with Cognitive Impairment,"* **Environment International,** 136, 2020: 105448.

Alvarez-Peregrina, C., Ssnchez-Tena, M.A., Andreu-Vázquez, C. & Villa-Collar, C. "*Visual Health and Academic Performance in School-Aged Children,*" **International Journal of Environmental Research and Public Health,** 17, 7, 2020: 2346.

Alwetaishi, M., Al-Khatri, H., Benjeddou, O., Shamseldin, A., Alsehli, M., Alghamdi, S. & Shrahily, R. "*An Investigation of Shading Devices in a Hot Region: A Case Study in a School Building,*" **Ain Shams Engineering Journal,** 12, 3, 2021: 3229-3239.

Alzahrani, H., Arif, M., Kaushik, A.K., Rana, M.Q. & Aburas, H.M. "*Evaluating the Effects of Indoor Air Quality on Teacher Performance Using Artificial Neural Network.*" **Journal of Engineering, Design and Technology***,* 21, 2, 2023: 604-618.

Amin, S.U., Ullah, U. & Din, M. *"Assessing Window Design for Healing Environment in Selected Hospitals,"* **Annals of Human and Social Sciences,** 5, 2, 2024: 695-702.

Amoatey, P., Al-Jabri, K., Al-Saadi, S., Al-Harthy, I. & Al-Khuzairi, M. *"Impact of Indoor Environmental Quality on Students' Comfort in High School Buildings during the Summer Season in an Extreme Climate,"* **Journal of Architectural Engineering***,* 29, 3, 2023: 04023014.

Ampollini, L., Katz, S. Bourne, E.F., Tian, Y., Novoselac, A., Goldstein, A.H., Lucic, G., Waring, M.S. & DeCarlo, P.F. *"Observations and Contributions of Real-Time Indoor Ammonia Concentrations during HOMEChem,"* **Environmental Science and Technology***,* 53, 15, 2019: 8591-8598.

Anenberg, S.C., Haines, S., Wang, E., Nassikas, N. & Kinney, P.L. "*Synergistic Health Effects of Air Pollution Temperature, and Pollen Exposure: A Systematic Review of Epidemiological Evidence,"* **Environmental Health***,* 19, 2020: 1-19.

Aparicio-Ruiz, P., Barbadilla-Martín, E., Guadix, J. & Munuzuri, J. "*A Field Study on Adaptive Thermal Comfort in Spanish Primary Classrooms during Summer Season,"* **Building and Environment***,* 203, 2021: 1-14. doi:https://doi.org/10.1016/j.buildenv.2021.108089

Arata, C., Misztal, P.K., Tian, Y., Lunderberg, D.M., Kristensen, K., Novoselac, A., Vance, M.E., Farmer, D.K., Nazaroff, W.W. & Goldstein, A.H. *"Volatile Organic Compound Emissions during HOMEChem,"* **Indoor Air***,* 31, 6, 2021: 2099-2117.

Arroyo, Y.P.V., Peñabaena-Niebles, R. & Correa, C.B. *"Influence of Environmental Conditions on Students' Learning Processes: A Systematic Review,"* **Building and Environment,** 231, 2023: 110051.

Arslan, H.D. & Yıldırım, K. *"Perceptual Evaluation of Traditional Turkish House Façade,"* **ICONARP International Journal of Architecture and Planning,** 2021.

Atyah, R. *"The Effects of the Physical Environment: A Critical Review,"* **The International Journal of Architectonic, Spatial, and Environmental Design,** 14, 3, 2020: 17.

Audu, A., Nimlyat, P., Jimoh, A., Umaru, A. & Bello, M.M. "*A Comparative Analysis of Subjective Thermal Comfort Perception in Selected Residential Building Typologies in Jos-Nigeria,"* **coou African Journal of Environmental Research,** 5, 1, 2024: 109-130.

Awada, M., Becerik-Gerber, B., Lucas, G. & Roll, S. "*Cognitive Performance, Creativity and Stress Levels of Neuro-Typical Young Adults under Different White Noise Levels,"* **Scientific Reports**, 12, 1, 2022: 14566.

Awosolu, O.B., Yahaya, Z.S., Haziqah, M.T.F., Simon-Oke, I.A. & Fakunle, C. "*A Cross-Sectional Study of the Prevalence, Density, and Risk Factors Associated with Malaria Transmission in Urban Communities of Ibadan, South-Western Nigeria,"* **Heliyon,** 7, 1, 2021: 59-75

Ayinla, A.K. & Adebisi, I.I. *"Investigating Indoor Ventilation in Multi-Habited Houses: A Case of Ogbomoso, Nigeria,"* **International Journal of Civil Engineering, Construction and Estate Management**, 9, 3, 2021: 1-15.

Ayoko, O.B., Ashkanasy, N.M., Li, Y., Dorris, A. & Jehn, K.A. *"An Experience Sampling Study of Employees' Reactions to Noise in the Open-Plan Office,"* **Journal of Business Research,** 155, 2023:113445.

Aziz, N., Adman, M.A., Suhaimi, N.S., Misbari, S., Alias, A.R., Abd Aziz, A., Lee, L.F. & Khan, M.M.H. *"Indoor Air Quality (IAQ) and Related Risk Factors for Sick Building Syndrome (SBS) at the Office and Home: A Systematic Review,"* In IOP Conference Series: **Earth and Environmental Science**, 1140, 1, 2023: 012007.

Baafi, R.K.A. "*School Physical Environment and Student Academic Performance,"* **Advances in Physical Education**, 10, 2, 2020: 121-137.

Baba, A., Shahrour, I. & Baba, M. *"Indoor Environmental Quality for Comfort Learning Environments: Case Study of Palestinian School Buildings,"* **Buildings**, 14, 5, 2024: 1296.

Baeza_Romero, M.T., Dudzinska, M.R., Amouei Torkmahalleh, M., Barros, N., Coggins, A.M., Ruzgar, D.G., Kildsgaard, I., Naseri, M., Rong, L., Saffell, J. & Scutaru, A.M. "*A Review of Critical Residential Buildings Parameters and Activities when Investigating Indoor Air Quality and Pollutants,"* **Indoor Air,** 32, 11, 2022: e13144.

Baloch, R.M., Maesano, C.N., Christoffersen, J., Banerjee, S., Gabriel, M., Csobod, E., de Oliveira Fernandes, E., Annesi-Maesano, I., Szuppinger, P., Prokai, R. & Farkas, P. *"Indoor Air Pollution, Physical and Comfort Parameters Related to School Children's Health: Data from the European SINPHONIE Study,"* **Science of the Total Environment**, 739, 2020: 139870.

Baloch, R.M., Nichole Maesano, C., Christoffersen, J., Mandin, C., Csobod, E., de Oliveira Fernandes, E., Annesi-Maesano, I. & Sinphonie, C. *"Daylight and School Performance in European School children,"* **International Journal of Environmental Research and Public Health,** 18, 1, 2021: 258.

Barksdale, C., Peters, M.L. & Corrales, A. *"Middle School Students' Perceptions of Classroom Climate and Its Relationship to Achievement,"* **Educational Studies,** 47, 1, 2021: 84-107.

Bassoud, A., Khelafi, H., Mokhtari, A.M. & Bada, A. *"Evaluation of Summer Thermal Comfort in Arid Desert Areas. Case Study: Old Adobe Building in Adrar (South of Algeria),"* **Building and Environment**, 205, 2021: 108140.

Bergefurt, L., Weijs-Perrée, M., Appel-Meulenbroek, R. & Arentze, T. *"The Physical Office Workplace as a Resource for Mental Health–A Systematic Scoping Review,"* **Building and Environment**, 207, 2022: 108505.

Bhandari, N., Tadepalli, S. & Gopalakrishnan, P. "*Investigation of Acoustic Comfort, Productivity, and Engagement in Naturally Ventilated University Classrooms: Role of Background Noise and Students' Noise Sensitivity,"* **Building and Environment,** 249, 2024: 111131.

Bhuda, M., Wichmann, J. & Shirinde, J. *"Association between Outdoor and Indoor Air Pollution Sources and Atopic Eczema among Pre-school Children in South Africa,"* **International Journal of Environmental Research and Public Health,** 21, 3, 2024: 326.

Bluyssen, P.M. *"Towards an Integrated Analysis of the Indoor Environmental Factors and Its Effects on Occupants,"* **Intelligent Buildings International,** 12, 3, 2020: 199-207.

Boissonneault, A. & Peters, T. *"Concepts of Performance in Post-Occupancy Evaluation Post-Probe: A Literature Review,"* **Building Research & Information**, 51, 4, 2023: 369-391.

Bouchama, A., Abuyassin, B., Lehe, C., Laitano, O., Jay, O., O'Connor, F.G. & Leon, L.R. *"Classic and Exertional Heatstroke,"* **Nature Reviews Disease Primers**, 8, 1, 2022: 8.

Breitenbach, M., Kapferer, E., Sedmak, C., Breitenbach, M., Kapferer, E. & Sedmak, C. *"Hans Selye and the Origins of Stress Research,"* **Stress and Poverty: A Cross-Disciplinary Investigation of Stress in Cells, Individuals, and Society,** 2021: 21-28.

Brink, H.W., Krijnen, W.P., Loomans, M.G., Mobach, M.P. & Kort, H.S. *"Positive Effects of Indoor Environmental Conditions on Students and their Performance in Higher Education Classrooms: A Between-Groups Experiment,"* **Science of the Total Environment,** 869, 2023: 161813.

Brink, H.W., Loomans, M.G., Mobach, M.P. & Kort, H.S. "*A Systematic Approach to Quantify the Influence of Indoor Environmental Parameters on Students' Perceptions, Responses, and Short-Term Academic Performance,*" **Indoor Air,** 32, 10, 2022: e13116.

Brink, H.W., Loomans, M.G., Mobach, M.P. & Kort, H.S. *"Classrooms' Indoor Environmental Conditions Affecting the Academic Achievement of Students and Teachers in Higher Education: A Systematic Literature Review,"* **Indoor Air**, 31, 2, 2021: 405-425.

Budiawan, W., Prastawa, H., Merdeka, G.F.P., Ari, S.M. & Phommachak, T. *"Field Survey Analysis of $CO_2$ Concentration and Its Impact on Sleep Efficiency in University Dormitory,"* IOP Conference Series: **Earth and Environmental Science**, 1268, 2023: 012072.

Bueno, A.M., de Paula Xavier, A.A. & Broday, E.E. *"Evaluating the Connection between Thermal Comfort and Productivity in Buildings: A Systematic Literature Review,"* **Buildings,** 11, 6, 2021: 244.

Bughio, M., Schuetze, T. & Mahar, W.A. *"Comparative Analysis of Indoor Environmental Quality of Architectural Campus Buildings' Lecture Halls and Its' Perception by Building Users in Karachi, Pakistan,"* **Journal of Sustainability,** 12, 7, 2020:1-29.

Bujang, M.A., Omar, E.D., Foo, D.H.P. & Hon, Y.K. "Sample Size Determination for Conducting a Pilot Study to Assess Reliability of a Questionnaire," **Restorative Dentistry & Endodontics**, 49, 1, 2024.

Burfoot, M., Ghaffarianhoseini, A., Naismith, N. & Ghaffarianhoseini, A. *"The Birth of Intelligent Passive Room Acoustic Technology: A Qualitative Review,"* **Smart and Sustainable Built Environment**, 12, 1, 2023: 60-83.

Campero, A., Vaccaro, M., Song, J., Wen, H., Almaatouq, A. & Malone, T.W. *"A Test for Evaluating Performance in Human-Computer Systems,*" **arXiv preprint arXiv;** 2206, 12390, 2022.

Carrington, V. "*Rethinking Middle Years: Early Adolescents, Schooling and Digital Culture*", **Routledge,** 2020.

Castilla, N., Higuera-Trujillo, J.L. & Llinares, C. "*The Effects of Illuminance on Students' Memory: A Neuro-Architecture Study,*" **Building and Environment,** 228, 2023: 109833.

Catalina, T., Ghita, S.A., Popescu, L.L. & Popescu, R. *"Survey and Measurements of Indoor Environmental Quality in Urban/Rural Schools Located in Romania,"* **International Journal of Environmental Research and Public Health**, 19, 16, 2022: 10219.

Caviola, S., Visentin, C., Borella, E., Mammarella, I. & Prodi, N. *"Out of the Noise: Effects of Sound Environment on Maths Performance in Middle-School Students,"* **Journal of Environmental Psychology,** 73, 2021: 101552.

Chen, D., Huebner, G., Bagkeris, E., Ucci, M. & Mumovic, D. *"Effects of Exposure to Moderate Pure Carbon Dioxide Levels on Cognitive Performance, Acute Health Symptoms and Perceived Indoor Environment Quality,"* **Acute Health Symptoms and Perceived Indoor Environment Quality**, 2023.

Chersich, M.F., Pham, M.D., Areal, A., Haghighi, M.M., Manyuchi, A., Swift, C.P., Wernecke, B., Robinson, M., Hetem, R., Boeckmann, M. & Hajat, S. *"Associations between High Temperatures in Pregnancy and Risk of Preterm Birth, Low Birth Weight, and Stillbirths: Systematic Review and Meta-Analysis,"* **Bmj**, 371, 2020.

Chinazzo, G., Wienold, J. & Andersen, M.J.L.R. *"Influence of Indoor Temperature and Daylight Illuminance on Visual Perception,"* **Lighting Research & Technology**, 52, 3, 2020: 350-370.

Choi, Y., Yoon, D. J., Lee, J. D., & Lee, J. Y. E. *"Relationship Conflict and Counter-Productive Work Behavior: The Roles of Affective Wellbeing and Emotional Intelligence,"* **Review of Managerial Science,** 18, 4, 2024: 1129-1148.

Cil, G. & Kim, J. *"Extreme Temperatures during Pregnancy and Adverse Birth Outcomes: Evidence from 2009 to 2018 US National Birth Data,"* **Health Economics,** 31, 9, 2022: 1993-2024.

Clark, C., Head, J., Haines, M., Van Kamp, I., Van Kempen, E. & Stansfeld, S.A. *"A Meta-Analysis of the Association of Aircraft Noise at School on Children's Reading Comprehension and Psychological Health for Use in Health Impact Assessment,"* **Journal of Environmental Psychology**, 76, 2021: 101646.

Commey-Mintah, P., Opoku, A., Kudjordji, S.K. & Awuah, F. *"Factors Influencing Students' Academic Performance: The Case of Pre-Service Teachers at Dambai College of Education in Ghana,"* **Education Quarterly Reviews,** 6, 1, 2023.

Dam-Krogh, E.P., Rupp, R.F., Clausen, G. & Toftum, J. *"Scoping Review of Post Occupancy Evaluation of Office Buildings with Focus on Indoor Environmental Quality and Productivity,"* **Journal of Building Engineering,** 2024: 108911.

Dębska, L. *"Assessment of the Indoor Environment in the Intelligent Building,"* **Civil and Environmental Engineering,** 17, 2, 2021: 572-582.

De Capua, C., Fulco, G., Lugara, M. & Ruffa, F. *"An Improvement Strategy for Indoor Air Quality Monitoring Systems,"* **Sensors**, 23, 8, 2023: 3999.

Dehghani, M.H., Zarei, A., Farhang, M., Kumar, P., Yousefi, M. & Kim, K.H. *"Levels of Formaldehyde in Residential Indoor Air of Gonabad, Iran,"* **Human and Ecological Risk Assessment: An International Journal**, 26, 2, 2020: 483-494.

Deng, Z., Dong, B., Guo, X. & Zhang, J. *"Impact of Indoor Air Quality and Multi-domain Factors on Human Productivity and Physiological Responses: A Comprehensive Review,"* **Indoor Air,** 2024, 2024.

Dhungana, P. & Chalise, M. "*Prevalence of Sick Building Syndrome Symptoms and Its Associated Factors among Bank Employees in Pokhara Metropolitan, Nepal,"* **Indoor Air,** 30, 2, 2020: 244-250.

Di, G., Wang, Y., Yao, Y., Ma, J. & Wu, J. *"Influencing Factors Identification and Prediction of Noise Annoyance: A Case Study on Substation Noise,"* **International Journal of Environmental Research and Public Health**, 19, 14, 2022: 8394.

Dimitroulopoulou, S., Dudzińska, M.R., Gunnarsen, L., Hägerhed, L., Maula, H., Visualisation, R.S., Visualisation, O.T, & Haverinen-Shaughnessy, U. *"Indoor Air Quality Guidelines from Across the World: An Appraisal Considering Energy Saving, Health, Productivity, and Comfort,"* **Environment International,** 2023: 108127.

Dlamini, S. & Tesfamichael, S.G. *"Approaches on the Concepts of Place Attachment in South Africa,"* **Geo-Journal,** 86(5), 2021: 2435-2445.

Donald, I. "*Environmental and Architectural Psychology: The Basics*," **Routledge,** 2022.

Dong, X., Wu, Y., Chen, X., Li, H., Cao, B., Zhang, X., Yan, X., Li, Z., Long, Y. & Li, X. *"Effect of Thermal, Acoustic, and Lighting Environment in Underground Space on Human Comfort and Work Efficiency: A Review,"* **Science of The Total Environment**, 786, 2021: 147537.

Dovjak, M., Kukec, A., Dovjak, M. & Kukec, A. *"Identification of Health Risk Factors and their Parameters,"* **Creating Healthy and Sustainable Buildings: An Assessment of Health Risk Factors**, 2019: 83-120.

Du, H., Lian, Z., Lai, D., Duanmu, L., Zhai, Y., Cao, B., Zhang, Y., Zhou, X., Wang, Z., Zhang, X. & Hou, Z. *"Evaluation of the Accuracy of PMV and Its Several Revised Models Using the Chinese Thermal Comfort Database,"* **Energy and Buildings**, 271, 2022: 112334.

Duan, Y. & Wu, J. *"Sport Tourist Perceptions of Destination Image and Revisit Intentions: An Adaption of Mehrabian-Russell's Environmental Psychology Model,"* **Heliyon,** 2024.

Dzwigol, H. *"Research Methodology in Management Science: Triangulation,"* **Virtual Economics**, 5, 1, 2022: 78-93.

Ebrahimi, Z., Patel, H., Wijk, H., Ekman, I. & Olaya-Contreras, P. "*A Systematic Review on Implementation of Person-Centered Care Interventions for Older People in Out-of-Hospital Settings,*" **Geriatric Nursing,** 42, 1, 2021: 213-224.

Ekmekci, A. & Serrano, D.M. "*The Impac of Teacher Quality on Student Motivation, Achievement, and Persistence in Science and Mathematics,*" **Education Sciences,** 12, 10, 2022: 649.

El Akili, Z., Bouzidi, Y., Merabtine, A., Polidori, G. & Chkeir, A. *"Experimental Investigation of Adaptive Thermal Comfort in French Healthcare Buildings,"* **Buildings,** 11, 11, 2021: 551.

El Zein, F. & Hijazi, R. *"Poor Indoor Environmental Quality leading to Sick Building Syndrome,"* **International Journal of Multidisciplinary and Current Educational Research (IJMCER),** 3, *6,* 2021:158-165.

Engineer, A., Gualano, R. J., Crocker, R. L., Smith, J. L., Maizes, V., Weil, A., & Sternberg, E.M.*"An Integrative Health Framework for Wellbeing in the Built Environment,"* **Building and Environment,** 205, 2021: 108253.

Etikan, I. & Bala, K. *"Sampling and Sampling Methods,"* **Biometrics & Biostatistics International Journal**, 5, 6, 2017, 1-49.

Everly, Jr., G.S., Lating, J.M., Everly, G.S. & Lating, J.M. *"The Concept of Stress,"* **A Clinical Guide to the Treatment of the Human Stress Response,** 2019: 3-18.

Ezeokoli, F.O., Omenyil, C.A., Bert-Okonkwo, C. B. N. & Iheama, N. B. *"The Perception of the Indoor Environment Quality (IEQ) of Private Hostels in Ifite-Awka, Nigeria,"* **Journal of Energy Research and Reviews,** 5, 3, 2020: 61-70.

Fahad, S. & Wang, J. *"Climate Change, Vulnerability, and Its Impacts in Rural Pakistan: A Review,"* **Environmental Science and Pollution Research,** 27, 2020: 1334-1338.

Fakhari, M., Vahabi, V. & Fayaz, R. *"A Study on the Factors Simultaneously Affecting Visual Comfort in Classrooms: A Structural Equation Modeling Approach,"* **Energy and Buildings**, 249, 2021: 111232.

Fan, X. & Zhu, Y. *"Effects of Indoor Temperature on Office Workers' Performance: An Experimental Study Based on Subjective Assessments, Neurobehavioral Tests, and Physiological Measurements,"* **Ergonomics,** 2023: 1-15.

Fantozzi, F. & Rocca, M. *"An Extensive Collection of Evaluation Indicators to Assess Occupants' Health and Comfort in Indoor Environment,"* **Atmosphere,** 11, 1, 2020: 90.

Faremi, J.O., Kukoyi, P.O., Edike, U.E., Sotunbo, A.S., Adenuga, O.A. & Koleoso, H.A. *"Energy Performance Benchmarking in University of Lagos Hostel Buildings,"* **Energy,** 10, 2, 2023.

Farooqi, Z.U.R., Ahmad, I., Ditta, A., Ilic, P., Amin, M., Naveed, A.B. & Gulzar, A. *"Types, Sources, Socio-Economic Impacts, and Control Strategies of Environmental Noise: A Review,"* **Environmental Science and Pollution Research,** 29, 54, 2022: 81087-81111.

Farrag, N., Abou El-Ela, M.A. & Ezzeldin, S. "*Sick Building Syndrome and Office Space Design in Cairo, Egypt,"* **Indoor and Built Environment,** 31, 2, 2022: 568-577.

Fazakas, E., Neamtiu, I.A. & Gurzau, E.S. *"Health Effects of Air Pollutant Mixtures (Volatile Organic Compounds, Particulate Matter, Sulfur and Nitrogen Oxides): A Review of the Literature,"* **Reviews on Environmental Health,** 0, 2023.

Fong, K.N., Ge, X., Ting, K.H., Wei, M. & Cheung, H. *"The Effects of Light Therapy on Sleep, Agitation and Depression in People with Dementia: A Systematic Review and Meta-Analysis of Randomized Controlled Trials,"* **American Journal of Alzheimer's Disease & Other Dementias,** 38, 2023: 15333175231160682.

Franke, M., & Nadler, C. *"Towards a Holistic Approach for Assessing the Impact of IEQ on Satisfaction, Health, and Productivity,"* **Building Research and Information,** 49, 4, 2021: 417-444.

Freewan, A.A. & Al- Dalala, J.A. *"Assessment of Daylight Performance of Advanced Daylighting Strategies in Large University Classrooms: Case Study Classrooms at JUST,"* **Alexandria Engineering Journal,** 59, 2, 2020: 791-802.

Fu, X., Feng, D., Jiang, X. & Wu, T. *"The Effect of Correlated Color Temperature and Illumination Level of LED Lighting on Visual Comfort during Sustained Attention Activities,"* **Sustainability**, 15, 4, 2023: 3826.

Gabbianelli, L. & Pencarelli, T. *"On-Campus Accommodation Service Quality: The Mediating Role of Students' Satisfaction on Word of Mouth,"* **The TQM Journal,** 2023.

Gabel, C., Elholm, G., Petersen, S. & Sigsgaard, T. *"Seasonal Indoor Air Quality, Self-Reported Health and Comfort amongst Tenants Living at Danish Multi-Family Social Housing Sites,"* **Indoor and Built Environment**, 2024

Ganesh, G.A., Sinha, S.L., Verma, T.N. & Dewangan, S.K. *"Investigation of Indoor Environment Quality and Factors Affecting Human Comfort: A Critical Review,"* **Building and Environment**, 204, 2021: 108-146.

Gangrade, S. & Sharma, A. "*Study of Thermal Comfort in Naturally Ventilated Educational Buildings of Hot and Dry Climate-A Case Study of Vadodara, Gujarat, India,"* **International Journal of Sustainable Building Technology and Urban Development,** 13, 1, 2022: 122-146.

Ganiyu, R.S. & Makinde, S. O. *"Towards Value Re-Orientation of Primary School Female Teachers on the Role of ICT in Teaching and Learning in Oyo Town, Nigeria,"* **Nigerian Online Journal of Educational Sciences and Technology,** 3, 1, 2021: 66-72.

Gao, J., Wang, H. & Liu, J. *"Comprehensive Assessment of Indoor Environmental Quality in High-Ceilinged Spaces,"* **Building and Environment,** 175, 2020: 106824.

Gbadegesin, F., Marais, L., Cloete, J., Rani, K., Lenka, M., Serekoane, M., Boivin, M., Shohet, C., Givon, D. & Sharp, C. *"Housing, Home and Children's Socio-Emotional Health: Conceptual Ideas and Empirical Evidence from a South African Pilot Study,"* **Housing, Theory and Society,** 39, 5, 2022: 555-572.

Gonzalez-Martin, J., Kraakman, N.J.R., Perez, C., Lebrero, R. & Munoz, R. *"A State–of–the-Art Review on Indoor Air Pollution and Strategies for Indoor Air Pollution Control,"* **Chemosphere,** 262, 2021: 128376.

Gupta, R., Howard, A. & Zahiri, S. *"Investigating the Relationship between Indoor Environment and Workplace Productivity in Naturally and Mechanically Ventilated Office Environments,"* **Building Services Engineering Research and Technology,** 41, 3, 2020: 280-304.

Hacini, C.E., Bada, Y. & Pihet, C. *"The Mobility of People with Disability: Between Urban Accessibility and Urban Attractiveness. A Case Study from Algiers, Algeria,"* **International review for spatial planning and sustainable development,** 10, 2, 2022: 38-57.

Halios, C.H., Landeg-Cox, C., Lowther, S.D., Middleton, A., Marczylo, T. & Dimitroulopoulou, S. *"Chemicals in European Residences - Part I: A Review of Emissions, Concentrations and Health Effects of Volatile Organic Compounds (VOCs),"* **Science of the Total Environment,** 839, 2022: 156201.

Hamed, A., Liu, Y., Wang, H. & Zheng, X. *"The Impact of Low Motivation on Students' Wellbeing in Poor IEQ Indoor Conditions: A Systematic Review,"* **Journal of Building Engineering,** 29, 2020: 101934.

Hao, H. & Conway, A.R. *"The Impact of Auditory Distraction on Reading Comprehension: An Individual Differences Investigation,"* **Memory & Cognition,** 50, 4, 2022: 852-863.

He, L., Xue, B., Wang, B., Liu, C., de Porras, D.G.R., Delclos, G.L., Ming, H., Bin, L. & Zhang, K. *"Impact of High, Low, and Non-Optimum Temperatures on Chronic Kidney Disease in a Changing Climate, 1990–2019: A Global Analysis,"* **Environmental Research,** 212, 2022: 113172.

He, W., Qiu, J., Fu, A. & Zheng, D. *"The Effect of Residential Mobility on the Intention of Social Environment Exploration for Emerging Adults,"* **Current Psychology,** 2021:1-6.

Heschong, L. "*Visual Delight in Architecture: Daylight, Vision, and View*," **Routledge**, 2021.

Hopkins, S., Black, A.A., White, S.L. & Wood, J.M. *"Visual Information Processing Skills are Associated with Academic Performance in Grade 2 School Children,"* **Acta ophthalmologica,** 97, 8, 2019: 1141-1148.

Horvath, D. & Borgonovi, F. *"Global Warming, Pollution and Cognitive Developments: The Effects of High Pollution and Temperature Levels on Cognitive Ability Throughout the Life Course,"* **OECD Social, Employment and Migration Working Papers,** 269, 2022: 1-68.

Hou, J., Sun, Y., Dai, X., Liu, J., Shen, X., Tan, H., Yin, H., Huang, K. Gao, Y., Lai, D. & Hong, W. *"Associations of Indoor Carbon Dioxide Concentrations, Air Temperature, and Humidity with Perceived Air Quality and Sick Building Syndrome Symptoms in Chinese Homes,"* **Indoor Air,** 31, 4, 2021: 1018-1028.

Hu, J., He, Y., Hao, X., Li, N., Su, Y. & Qu, H. *"Optimal Temperature Ranges Considering Gender Differences in Thermal Comfort, Work Performance, and Sick Building Syndrome: A Winter Field Study in University Classrooms,"* **Energy and Buildings,** 254, 2022: 111554.

Hu, J., Li, N., Zou, S., Yoshino, H., Yanagi, U., Yu, C.W. & Qu, H. *"Indoor Environmental Conditions in School Children's Homes in Central-South China,"* **Indoor and Built Environment,** 29, 7, 2020: 956-971.

Hu, M. & Ming, H. *"Indoor Environmental Impact on Human Health,"* **Smart Technologies and Design for Healthy Built Environments,** 2021: 57-74.

Huo, X., Sun, Y., Hou, J., Wang, P., Kong, X., Zhang, Q. & Sundell, J. *"Sick Building Syndrome Symptoms among Young Parents in Chinese Homes,"* **Building and Environment,** 169, 2020: 106283.

Hviid, C.A., Pedersen, C. & Dabelsteen, K.H. *"A Field Study of the Individual and Combined Effect of Ventilation Rate and Lighting Conditions on Pupils' Performance,"* **Building and Environment***,* 171, 2020: 106608.

Hwang, R.L., Liao, W.J. & Chen, W.A. "*Optimization of Energy Use and Academic Performance for Educational Environments in Hot-Humid Climates*," **Building and Environment***,* 222, 2022: 109434.

Indraganti, M., Kutty, F., Ali, R., Al Noaimi, L., Al-Bader, S. & Al Mulla, M.A. *"Occupant Perception of Thermal Comfort in Sleep Environments in Qatar,"* **The Journal of Engineering Research (TJER)***,* 18, 2, 2021: 137-145.

Ingole, V., Sheridan, S.C., Juvekar, S., Achebak, H. & Moraga, P. *"Mortality Risk Attributable to High and Low Ambient Temperature in Pune City, India: A Time Series Analysis from 2004 to 2012,"* **Environmental Research,** 204, 2022: 112304.

Ioannou, L.G., Mantzios, K., Tsoutsoubi, L., Notley, S.R., Dinas, P.C., Brearley, M., Epstein, Y., Havenith, G., Sawka, M.N., Brode, P. & Mekjavic, I.B. *"Indicators to Assess Physiological Heat Strain–Part 1: Systematic Review,"* **Temperature,** 9, 3, 2022: 227-262.

Ireri, E.M., Mukirae, N. & Otieno, M. *"Influence of Infrastructural Facilities and Staffing on Students' Academic Performance in National Secondary Schools in Kenya,"* **East African Journal of Education Studies,** 5, 2, 2022: 175-185.

Itebimien, O. *"Ambient Air Quality Monitoring of an Educational Institution in Nigeria,"* **Coast Journal of the School of Science OAUSTECH Okitipupa,** 5, 1, 2023: 864-874.

Iyakaremye, V., Zeng, G., Yang, X., Zhang, G., Ullah, I., Gahigi, A., Vuguziga, F., Asfaw, T.G. & Ayugi, B. *"Increased High-Temperature Extremes and Associated Population Exposure in Africa by The Mid-21st Century,"* **Science of the Total Environment,** 790, 2021: 148162.

Jacob, F., John, S. & Gwany, D.M. *"Teachers' Pedagogical Content Knowledge and Students' Academic Achievement: A Theoretical Overview,"* **Journal of Global Research in Education and Social Science,** 14, 2, 2020: 14-44.

Jin, Q. & Wallbaum, H. *"Improving Indoor Environmental Quality (IEQ) for Occupant Health and Well-Being: A Case Study of Swedish Office Building,"* In IOP Conference Series: **Earth and Environmental Science**, 588, 3, 2020: 032072.

Jin, S., Zhong, L., Zhang, X., Li, X., Li, B. & Fang, X. *"Indoor Volatile Organic Compounds: Concentration Characteristics and Health Risk Analysis on a University Campus,"* **International Journal of Environmental Research and Public Health,** 20, 10, 2023: 5829.

Jobi, A., Ogunbodede, B. & Tongo, S. *"Design Characteristics and Crime Experience in University Students Halls of Residence,"* **Kufa Journal of Engineering,** 13, 4, 2022: 1-12.

Johnson, C. C., Havstad, S. L., Ownby, D. R., Joseph, C. L., Sitarik, A. R., Myers, J. B. & Gern, J. E. *"Pediatric Asthma Incidence Rates in the United States from 1980 to 2017,"* **Journal of Allergy and Clinical Immunology,** *148,* 5, 2021: 1270-1280.

Joshi, N. & Patki, P. *"Relationship of Shading Devices and Its Effects on Daylight in Commercial Buildings in Pune,"* IOP Conf. Series: **Earth Environmental Science**, 1084, 2022: 012079

Jowkar, M., Rijal, H.B., Montazami, A., Brusey, J. & Temeljotov-Salaj, A. *"The Influence of Acclimatization, Age and Gender-Related Differences on Thermal Perception in University Buildings: Case Studies in Scotland and England,"* **Building and Environment**, 2020.

Juan, Y.K. & Chen, Y. *"The Influence of Indoor Environmental Factors on Learning: An Experiment Combining Physiological and Psychological Measurements,"* **Building and Environment**, 221, 2022: 109299.

Kakoulli, C., Kyriacou, A. & Michaelides, M.P. "*A Review of Field Measurement Studies on Thermal Comfort, Indoor Air Quality and Virus Risk,"* **Atmosphere**, 13, 2, 2022: 191.

Kalender-Smajlovic, S., Kukec, A. & Dovjak, M. "*The Problem of Indoor Environmental Quality at a General Slovenian Hospital and Its Contribution to Sick Building Syndrome*," **Building and Environment,** 214, 2022: 108908.

Kalender Smajlović, S., Kukec, A. & Dovjak, M. "*Association between Sick Building Syndrome and Indoor Environmental Quality in Slovenian Hospitals: A Cross-Sectional Study,"* **International Journal of Environmental Research and Public Health,** 16, 17, 2019: 3224.

Kang, J. & Zang, Y. *"Noise Reduction Performance of High-rise Buildings,"* **Applied Acoustics,** 146, 2019: 227-235.

Kang, J., Lee, J. & Kim, J. *"Impact of Window Orientation on Indoor Environmental Quality in Office Buildings,"* **Journal of Building Engineering,** 25, 2019: 100924.

Kapoor, N.R., Kumar, A., Alam, T., Kumar, A., Kulkarni, K.S. & Blecich, P. *"A Review on Indoor Environment Quality of Indian School Classrooms,"* **Sustainability,** 13, 21, 2021: 11855.

Kapoor, N.R., Kumar, A., Meena, C.S., Kumar, A., Alam, T., Balam, N.B. & Ghosh, A. *"A Systematic Review on Indoor Environmental Quality in Naturally Ventilated School Classrooms: A Way Forward,"* **Advances in Civil Engineering,** 2021, 2021: 1-19.

Kasap, E.Z., Ağzıtemiz, F. & Ünal, G. *"Cognitive, Mental and Social Benefits of Interacting with Nature: A Systematic Review."* **Journal of Happiness and Health,** 1, 1, 2021:16-27.

Kaur, J. *"Academic Performance of the Children with Visual and Hearing Impairment in Special Schools,"* **Journal of Contemporary Issues in Business and Government**, 25, 1, 2019.

Kaushik, A., Arif, M., Ebohon, O.J., Arsalan, H., Rana, M.Q. & Obi, L. *"Effect of Indoor Environmental Quality on Visual Comfort and Productivity in Office Buildings,"* **Journal of Engineering, Design and Technology,** 21, 6, 2023: 1746-1766.

Kaushik, A.K., Arif, M., Syal, M.M., Rana, M.Q., Oladinrin, O.T., Sharif, A.A. & Alshdiefat, A.A.S. *"Effect of Indoor Environment on Occupant Air Comfort and Productivity in Office Buildings: A Response Surface Analysis Approach,"* **Sustainability***,* 14, 23, 2022: 15719.

Kaushik, A., Arif, M., Tumula, P.T. & Ebohon, O.J. *"Effect of Thermal Comfort on Occupant Productivity in Office Buildings: Response Surface Analysis."* **Building and Environment,** 180, 2020: 107021.

Ketema, R.M., Araki, A., Ait Bamai, Y., Saito, T. & Kishi, R. *"Lifestyle Behaviors and Home and School Environment in Association with Sick Building Syndrome among Elementary School Children: A Cross-Sectional Study,"* **Environmental Health and Preventive Medicine***,* 25, 2020: 1-11.

Khamis, N.S.N., Zainal, R., Musa, S.M.S. & Kasim, N. *"Adaptation of Thermal Comfort in Naturally Ventilated Students Residential College in Tropical Climates of Malaysia,"* **International Journal of Engineering Technology Research & Management,** 5, 6, 2021: 150-158.

Khan, F.R., Shekili, A., Said, N., Al Badi, A.S. & Al Khanbashi, H.A. "Exploring the Impact of Hostel Life of Students on Academic Performance: Sohar University–A Case Study." **International Journal of Research in Entrepreneurship & Business Studies***,* 1, 1, 2020: 1-14.

Khan, A.H.; Sultana, S.; Hossain, S.; Hasan, M.T.; Ahmed, H.U. & Sikder, M.T. *"The Impact of COVID-19 Pandemic on Mental Health and Wellbeing among Home-Quarantined Bangladeshi Students: A Cross-Sectional Pilot Study,"* **Journal of Affection Disorder,** 277, 2020: 121–128

Khan, J., Hussain, T., Javed, M.T. & Meraj, S. *"Effect of Indoor Environmental Quality on Human Comfort and Performance: A Review,"* **Ergonomics for Improved Productivity: Proceedings of HWWE 2017***,* 2, 2022: 335-345.

Khaznadar, B.M.A. & Bapir, S.Y. *"Sustainable Continuity of Cultural Heritage: An Approach for Studying Architectural Identity Using Typo-Morphology Analysis and Perception Survey,"* **Sustainability***,* 15, 11, 2023: 9050.

Khovalyg, D. Berquand, C.A., Vergerio, G., Barthelmes, V.M., Chatterjee, A., Becchio, C. & Licina, D. "*Energy, SBS Symptoms, and Productivity in Swiss Open-Space Offices: Economic Evaluation of Standard, Actual, and Optimum Scenarios,"* **Building and Environment,** 242, 2023: 110565.

Khovalyg, D., Kazanci, O.B., Halvorsen, H., Gundlach, I., Bahnfleth, W.P., Toftum, J. & Olesen, B.W. *"Critical Review of Standards for Indoor Thermal Environment and Air Quality,"* **Energy and Buildings,** 213, 2020: 109819.

Kim, J., Ryu, J., Jeong, B. & de Dear, R. *"Semantic Discrepancies between Korean and English Versions of the ASHRAE Sensation Scale,"* **Building and Environment***,* 221, 2022: 109343.

Kim, J., Lee, J. & Kim, B. "*Thermal Performance of I-Shaped Buildings: A Case Study*," **Energy and Buildings,** 151, 2017: 311-319

Kim, T.H., Lee, H., Choi, B.H. & Hyun, H.S. *"A Pilot Study of Improving the Atmospheric Environment of Classroom for Students' Learning Activities,"* **Journal of People, Plants, and Environment***,* 24, 2, 2021: 179-194.

Knudsen, J.B., Pinder, M., Jatta, E., Jawara, M., Yousuf, M.A. & Søndergaard, A.T. "*Measuring Ventilation in Different Typologies of Rural Gambian Houses: A Pilot Experimental Study,"* **Malaria Journal,** 19, 2020: 1-11.

Kong, Z., Liu, Q., Li, X., Hou, K. & Xing, Q. *"Indoor Lighting Effects on Subjective Impressions and Mood States: A Critical Review,"* **Building and Environment***,* 224, 2022: 109591.

Konstantzos, I., Sadeghi, S.A., Kim, M., Xiong, J. & Tzempelikos, A. *"The Effect of Lighting Environment on Task Performance in Buildings: A Review,"* **Energy and Buildings***,* 226, 2020: 110394.

Korkmaz, D., Knauth, K., Brands, A.M., Schmeck, M., Buening, P. & Peters, J. *"Ambulatory Physiological Measures Obtained under Naturalistic Urban Mobility Conditions have Acceptable Reliability,"* **BioRxiv,** 2024-04, 2024.

Korpal, P. *"Stress and Emotion in Conference Interpreting: In The Routledge Handbook of Conference Interpreting,"* **Routledge,** 2021: 401-413.

Korsavi, S.S., Montazami, A. & Mumovic, D. *"Perceived Indoor Air Quality in Naturally Ventilated Primary Schools in the UK: Impact of Environmental Variables and Thermal Sensation,"* **Indoor Air***,* 31, 2, 2021: 480-501.

Korsavi, S.S., Montazami, A. & Mumovic, D. *"The Impact of Indoor Environment Quality (IEQ) on School Children's Overall Comfort in the UK; A Regression Approach,"* **Building and Environment,** 185, 2020: 107309.

Kozesaz-Zade, M. & Yeghane, M. *"Comparing the Mental Reconstruction of Nature in Architecture with the Theory of Rehabilitation of Attention and Concentration and the Theory of Sensory Function,"* **International Journal,** 1, 4, 2023.

Kubozono, T., Akasaki, Y., Kawasoe, S., Ojima, S., Kawabata, T., Makizako, H., Kuwahata, S., Takenaka, T., Maeda, M., Ohno, M. & Kijimuta, M. *"The Relationship between Home Blood Pressure Measurement and Room Temperature in a Japanese General Population,"* **Hypertension Research,** 44, 4, 2021: 454-463.

Kuhlenengel, M., Konstantzos, I. & Waters, C.E. *"The Effects of the Visual Environment on K-12 Student Achievement,"* **Buildings***,* 11, 11, 2021: 498.

Kumar, P., Singh, A.B., Arora, T., Singh, S. & Singh R. *"Critical Review on Emerging Health Effects Associated with the Indoor Air Quality and Its Sustainable Management,"* **Science of The Total Environment**, 872, 2023: 162-163.

Kumar, P., Singh, M. & Gupta, R. *"Effect of Sliding Windows on Indoor Air Quality and Ventilation in Hostel Rooms,"* **Building and Environment,** 155, 2019: 106824.

Kumar, S. & Singh, M.K. *"Seasonal Comfort Temperature and Occupant's Adaptive Behaviour in a Naturally Ventilated University Workshop Building under the Composite Climate of India,"* **Journal of Building Engineering,** 40, 2021: 102701.

Kumar, S., Mathur, A., Singh, M.K. & Rana, K.B. *"Adaptive Thermal Comfort Study of Workers in a Mini-Industrial Unit during Summer and Winter Season in a Tropical Country, India,"* **Building and Environment,** 197, 2021: 107874.

Kunle, A.A., Ismail, A.I., Adedayo, O.O. & Oloruntoba, A.E. *"Thermal Indices Influence on Occupants' Window Opening Behaviours: A case of Ibadan and Ogbomoso, Oyo State, Nigeria,"* **Journal of Architectural Environment & Structural Engineering Research**, 4, 1, 2021: 18-27.

Kusumaningrum, W.R. & Asmara, R. *"Does Active Learning Method for Higher Education Promote Students' Learning? (Students-Teachers Perceptions towards the Implementation of Active Learning Method),"* **Journal of English Language and Education**, 5, 2, 2019: 113-119.

Lala, B. & Hagishima, A. *"A Review of Thermal Comfort in Primary Schools and Future Challenges in Machine Learning Based Prediction for Children,"* **Buildings**, 12, 11, 2022: 2007.

Lamberti, G., Salvadori, G., Leccese, F., Fantozzi, F. & Bluyssen, P.M. *"Advancement on Thermal Comfort in Educational Buildings: Current Issues and Way Forward,"* **Sustainability**, 13, 18, 2021: 10315.

Lan, L., Tang, J., Wargocki, P., Wyon, D.P. & Lian, Z. *"Cognitive Performance was Reduced by Higher Air Temperature even when Thermal Comfort was Maintained Over the 24–28$^0$ C Range,"* **Indoor Air**, 32, 1, 2022: e12916.

Lan, L., Wargocki, P. & Lian, Z. *"Quantitative Measurement of Productivity Loss due to Thermal Discomfort in Single Banked Buildings,"* **Building and Environment,** 175, 2020: 106824.

Larsen, L.T. *"Not Merely the Absence of Disease: A Genealogy of the WHO's Positive Health Definition,"* **History of the Human Sciences,** 35, 1, 2022: 111-131.

Lawal, L.T. *"Assessment of Natural Ventilation in Multi-Storey Residential in Abuja, Nigeria,"* **Journal of Built Environment and Geological Research,** 2023.

Lee, E.S., Matusiak, B.S., Geisler-Moroder, D., Selkowitz, S.E. & Heschong, L. *"Advocating for View and Daylight in Buildings: Next Steps,"* **Energy and Buildings,** 265, 2022: 112079

Lee, J., Kang, J., Gagliano, A., Kim, J., Matusiak, B., Mudarri, D. & Lan, L. *"Combined Effects of Opposite Walls on Indoor Environmental Quality,"* **Building and Environment,** 175, 2020: 106824.

Lee, J., Kang, J., Kim, J. & Matusiak, B. *"Effects of Window Openings on Indoor Environmental Quality: A Review,"* **Building and Environment,** 175, 2020: 106824.

Lee, J., Lee, Y. & Kim, B. *"Impact of Building Height on Daylighting in Office Spaces,"* **Journal of Building Engineering,** 20, 2018: 111-118.

Lee, Y., Wargocki, P., Chan, Y.H., Chen, L. & Tham, K.W. *"How Does Indoor Environmental Quality in Green Refurbished Office Buildings Compare with the One in New Certified Buildings?"* **Building and Environment,** 171, 2020: 106677.

Leist, L., Breuer, C., Yadav, M., Fremerey, S., Fels, J., Raake, A., Lachmann, T., Schlittmeier, S.J. & Klatte, M. *"Differential Effects of Task-Irrelevant Monaural and Binaural Classroom Scenarios on Children's and Adults' Speech Perception, Listening Comprehension, and Visual–Verbal Short-Term Memory,"* **International Journal of Environmental Research and Public Health,** 19, 23, 2022: 15998.

Lekan-Kehinde, M. & Asojo, A. *"Impact of Lighting on Children's Learning Environment: A Literature Review,"* **WIT Trans. Ecol. Environment,** 253, 2021: 371-380.

Leslie, C.E. *"Interaction Patterns and Support for Learning in the Primary Foreign Language Classroom,"* **Porta Linguarum Revista Interuniversitaria de Didáctica de las Lenguas Extranjeras***,* 36, 2021: 65-82.

Leung, M.Y., Sieh, L. & Yin, R. *"An Integrated Model for Luminous Environment and Quality of Life of Older People in Care and Attention Homes,"* **Building and Environment***,* 2023: 110821.

Li, A.J., Pal, V.K. & Kannan, K. *"A Review of Environmental Occurrence, Toxicity, Biotransformation and Biomonitoring of Volatile Organic Compounds,"* **Environmental Chemistry and Ecotoxicology,** 3, 2021: 91-116.

Li, R., Cheng, X., Schwebel, D.C., Yang, Y., Ning, P., Cheng, P. & Hu, G. *"Disability-Adjusted Life Years Associated with Population Ageing in China, 1990-2017,"* **BMC geriatrics,** 21, 1, 2021: 369.

Li, S., Zhang, X., Li, Y., Gao, W., Xiao, F. & Xu, Y. *"A Comprehensive Review of Impact Assessment of Indoor Thermal Environment on Work and Cognitive Performance-Combined Physiological Measurements and Machine Learning,"* **Journal of Building Engineering,** 2023: 106417.

Liman, I.A. *"Performance Evaluation of Public Secondary School Hostel Buildings in Niger State,"* **Journal of Environmental Design & Construction Management**, 20, 4, 2021: 139-151.

Liu, H., Ma, X., Zhang, Z., Cheng, X., Chen, Y. & Kojima, S. *"Study on the Relationship between Thermal Comfort and Learning Efficiency of Different Classroom-Types in Transitional Seasons in the Hot Summer and Cold Winter Zone of China,"* **Energies,** 14, 19, 2021: 6338.

Liu, Q., Huang, Z., Li, Z., Pointer, M.R., Zhang, G., Liu, Z., Gong, H. & Hou, Z. *"A Field Study of the Impact of Indoor Lighting on Visual Perception and Cognitive Performance in Classroom,"* **Applied Sciences,** 10, 21, 2020: 7436.

Liu, W., Tian, X. & Tao, M. *"A Model to Quantify the Relation between Cognitive Performance and Thermal Responses in High Temperature at a Moderate Activity Level,"* **Building and Environment**, 207, 2022: 108431.

Liu, Y., Hamed, A. & Wang, H. *"The Effects of IEQ Conditions on Students' Mental Health and Wellbeing,"* **Building and Environment,** 155, 2019: 106824.

Liu, Y., Hamed, A. & Wang, H. *"The Effects of Low Motivation on Students' Mental Health in Poor IEQ Indoor Conditions,"* **Building and Environment,** 155, 2019: 106824.

Lolli, F., Marinello, S., Coruzzolo, A.M. & Butturi, M.A. *"Post-Occupancy Evaluation's (POE) Applications for Improving Indoor Environment Quality (IEQ),"* **Toxics,** 10, 10, 2022: 626.

Lopez-Chao, V., Amado Lorenzo, A., Saorín, J.L., De La Torre-Cantero, J. & Melián-Díaz, D. *"Classroom Indoor Environment Assessment through Architectural Analysis for the Design of Efficient Schools,"* **Sustainability,** 12, 5, 2020: 2020.

Lowther, S.D., Dimitroulopoulou, S., Foxall, K., Shrubsole, C., Cheek, E., Gadeberg, B. & Sepai, O. *"Low Level Carbon Dioxide Indoors: a Pollution Indicator or a Pollutant? A Health-Based Perspective,"* **Environments**, 8, 11, 2021: 125.

Lu, W., Hackman, D.A. & Schwartz, J. *"Ambient Air Pollution Associated with Lower Academic Achievement among US Children: A Nationwide Panel Study of School Districts,"* **Environmental Epidemiology,** 5, 6, 2021: e174.

Mac Domhnaill, C., Douglas, O., Lyons, S., Murphy, E. & Nolan, A. *"Road Traffic Noise and Cognitive Function in Older Adults: A Cross-Sectional Investigation of the Irish Longitudinal Study on Ageing,"* **BMC Public Health,** 21, 2021: 1-14.

Madhavi, I., Farsana, K., Reem, A., Lulwa, A., Saeeda, A. & Maryam, A.A. *"Occupant Perception of Thermal Comfort in Sleep Environments in Qatar,"* **The Journal of Engineering Research (TJER),** 18, 2, 2021: 137-145.

Mahfoudh, R. & Ghabra, N. *"Study of Active Design Strategies to Enhance Physical Activity in University Educational Buildings: A Case Study at King Abdulaziz University,"* **Journal of Umm Al-Qura University for Engineering and Architecture,** 14, 4, 2023: 241-270.

Maigari, M., Fu, C., Deng, J. & Bahadori-Jahromi, A. *"Indoor Environmental Quality Study for Higher Education Buildings,"* **Advancements in Indoor Environmental Quality and Health, IntechOpen.** 2023. doi: 10.5772/intechopen.113332

Majewski, G., Orman, Ł.J., Telejko, M., Radek, N., Pietraszek, J. & Dudek, A. *"Assessment of Thermal Comfort in the Intelligent Buildings in View of Providing High Quality Indoor Environment,"* **Energies***,* 13, 8, 2020: 1973.

Malik, S., Hazarika, D.D. & Dhaliwal, A. *"Deliverables of Student Engagement: Developing an Outcome-Oriented Model,"* **Journal of International Education in Business,** 15, 2, 2022: 221-249.

Mamani, T., Herrera, R.F., Muñoz-La Rivera, F. & Atencio, E. *"Variables that Affect Thermal Comfort and Its Measuring Instruments: A Systematic Review,"* **Sustainability**, 14, 3, 2022: 1773.

Manca, S., Cerina, V., Tobia, V., Sacchi, S. & Fornara, F. *"The Effect of School Design on Users' Responses: A Systematic Review (2008–2017),"* **Sustainability,** 12, 8, 2020: 3453.

Mancini, F., Nardecchia, F., Groppi, D., Ruperto, F. & Romeo, C. *"Indoor Environmental Quality Analysis for Optimizing Energy Consumptions Varying Air Ventilation Rates,"* **Sustainability***,* 12, 2, 2020: 482.

Mannan, M. & Al-Ghamdi, S.G. *"Indoor Air Quality In Buildings: A Comprehensive Review on the Factors Influencing Air Pollution in Residential and Commercial Structure,"* **International Journal of Environmental Research and Public Health,** 18, 6, 2021: 3276.

Martins, L.A., Soebarto, V. & Williamson, T. *"A Systematic Review of Personal Thermal Comfort Models,"* **Building and Environment,** 207, 2022: 108502.

Martins, O.A., Johnson, A.M., Alabi, S.I., Awarun, O., Oladejobio, J.O., Rasheedat, M.O. & Maiye, C.A. *"Occupation-Related Stress among University Faculty Staff in Kwara State, Nigeria,"* **Ushus Journal of Business Management,** 20, 1, 2021: 15.

Martinez-Perez, C., Alvarez-Peregrina, C., Brito, R., Sanchez-Tena, M.A. & Grupo de Investigação, O.I.L. *"The Evolution and the Impact of Refractive Errors on Academic Performance: A Pilot Study of Portuguese School-Aged Children,"* **Children**, 9, 6, 2022: 840.

Marval, J. & Tronville, P. *"Ultrafine Particles: A Review about their Health Effects, Presence, Generation, and Measurement in Indoor Environments,"* **Building and Environment,** 216, 2022: 108992.

Mason, L., Ronconi, A., Scrimin, S. & Pazzaglia, F. *"Short-Term Exposure to Nature and Benefits for Students' Cognitive Performance: A Review,"* **Educational Psychology Review**, 34, 2, 2022: 609-647.

Matusiak, B.S. & Knez, I. "*Impact of Building Geometry on Daylighting in Office Spaces,"* **Journal of Building Engineering,** 9, 2017: 111-119.

Mba, E.J. Okeke, F.O. & Okoye, U. *"Effects of Wall Openings on Effective Natural Ventilation for Thermal Comfort in Classrooms of Primary Schools in Enugu Metropolis, Nigeria,"* **JP Journal of Heat and Mass Transfer,** 22, 2, 2021: 269-304.

McClain, M.B., Yoho, S.E., Drill, R.B., Haverkamp, C.R., Schwartz, S.E., Barker, B.A., Longhurst, D.N. & Upton, S.R. *"Reading Skills and Background Noise in Autistic and Non-autistic Children: A Pilot Study,"* **Contemporary School Psychology,** 2023: 1-13.

Meagher, B.R. *"Ecologizing Social Psychology: The Physical Environment as a Necessary Constituent of Social Processes,"* **Personality and Social Psychology Review,** 24(1), 2020: 3-23.

Mealings, K. *"A Scoping Review of the Effect of Classroom Acoustic Conditions on Primary School Children's Numeracy Performance and Listening Comprehension,"* **Acoustics Australia,** 51, 1, 2023: 129-158.

Mealings, K. *"Classroom Acoustics and Cognition: A Review of the Effects of Noise and Reverberation on Primary School Children's Attention and Memory,"* **Building Acoustics,** 29, 3, 2022: 401-431.

Minelli, G., Puglisi, G.E. & Astolfi, A. *"Acoustical Parameters for Learning In Classroom: A Review,"* **Building and Environment,** 208, 2022: 108582.

Mirzaei, N., Kamelnia, H., Islami, S.G., Kamyabi, S. & Assadi, S.N. *"The Impact of Indoor Environmental Quality of Green Buildings on Occupants' Health and Satisfaction: A Systematic Review,"* **Journal of Community Health Research,** 2020.

Mogas-Recalde, J., Palau, R. & Márquez, M. *"How Classroom Acoustics Influence Students and Teachers: A Systematic Literature Review,"* **Journal of Technology and Science Education,** 11, 2, 2021: 245-259.

Mohajan, H.K. “*Quantitative Research: A Successful Investigation in Natural and Social Sciences,”* **Journal of Economic Development, Environment and People,** 9, 4, 2020: 50-79.

Mohamed, A.M.O., Paleologos, E.K. & Howari, F.M. *"Noise Pollution and Its Impact on Human Health and the Environment,"* ***In Pollution Assessment for Sustainable Practices in Applied Sciences and Engineering,*** 2021: 975-1026.

Mohebian, Z., Dehghan, H. & Hoseinbore, M. *"Investigating the Effects of Different Levels of Lighting on the Attention Index of Male and Female: An Experimental Study,"* **International Journal of Environmental Health Engineering,** 12, 5, 2023: 24.

Mokhtari, R., Dehghan, N. & Maleki, A. *“Analysis of the Impact of Window Properties on the Main Living Space with the Aim of Daylight Efficiency and Energy Saving in the Hot and Dry Climate of Isfahan,”* **Journal of Solar Energy Research***,* 8, 1, 2023: 1235-1249.

Monge-Barrio, A., Bes-Rastrollo, M., Dorregaray-Oyaregui, S., González-Martínez, P., Martin-Calvo, N., López-Hernández, D., Arriazu-Ramos, A. & Sánchez-Ostiz, A. *“Encouraging Natural Ventilation to Improve Indoor Environmental Conditions at Schools. Case Studies in the North of Spain Before and During COVID,”* **Energy and Buildings***,* 254, 2022: 111567.

Mostepaniuk, A., Nasr, E., Awwad, R.I., Hamdan, S. & Aljuhmani, H.Y. *"Managing a Relationship between Corporate Social Responsibility and Sustainability: A Systematic Review,"* **Sustainability,** 14, 18, 2022: 11203.

Mudarri, D., Fisk, W.J. & Sunderesan, S. *“Indoor Humidity and Moisture in Buildings,”* **Journal of Building Engineering,** 5, 2016: 137-145.

Munonye, C. & Ji, Y. *"Evaluating the Perception of Thermal Environment in Naturally Ventilated Schools in A Warm and Humid Climate in Nigeria,"* **Building Services Engineering Research and Technology,** 42, 1, 2021: 5-25.

Munonye, C. & Ji, Y. *“Investigating the Comfort Temperature for School Children in a Warm and Humid Climate of Imo State, Nigeria,”* **African Journal of Environmental Research,** 2, 1, 2020: 76-89.

Munonye, C.C., Ifebi, O.C., Odimegwu, C.N., Chukwu, I.N. & Ohaegbu, P.N. *"Comparative Analysis of Comfort Temperature of Children and their Teachers,"* **Only One Earth,** 2022: 406.

Munonye, C.C., Ohaegbu, P.N., Chukwu, I.N., Ifebi, O.C. & Odimegwu, C.N. *“Upper Limit of Acceptable Temperature for Children in Naturally Ventilated Classrooms in Warm Humid Climate in Imo State, Nigeria,”* In IOP Conference Series: **Earth and Environmental Science**, 2022: 012055

Musa, A.H., Bello, M.M., Evelyn, L.A & Pontip, S. *"Assessment of Thermal Comfort in Studios of the Department of Architecture, Abubakar Tafawa Balewa University, Bauchi, Yelwa Campus,"* **Archiculture**, 5, 2, 2023: 92-103.

Mustapha, T.D., Hassan, A.S., Khozaei, F. & Onubi, H.O. *"Examining Thermal Comfort Levels and ASHRAE Standard-55 Applicability: A Case Study of Free-Running Classrooms in Abuja, Nigeria."* **Indoor and Built Environment**, 33, 1, 2024: 8-22.

MZ, Z.H. & Saliluddin, S.M. *"A Review of Studies Related to Sick Building Syndrome among Office Workers,"* **International Journal of Public Health and Clinical Sciences,** *6,* 2, 2019: 21-43.

Nagare, R., Woo, M., MacNaughton, P., Plitnick, B., Tinianov, B. & Figueiro, M. *"Access to Daylight at Home Improves Circadian Alignment, Sleep, and Mental Health in Healthy Adults: A Cross-over Study,"* **International Journal of Environmental Research and Public Health,** 18, 19, 2021: 9980.

Navy, S.L. "*Theory of Human Motivation: Abraham Maslow,"* **Science Education in Theory and Practice: An Introductory Guide to Learning Theory,** 2020: 17-28.

Nduka, D.O., Oyeyemi, K.D., Olofinnade, O.M., Ede, A.N. & Worgwu, C. *"Relationship between Indoor Environmental Quality and Sick Building Syndrome: A Case Study of Selected Student's Hostels in South-Western Nigeria,"* **Cogent Social Sciences,** 7, 1, 2021: 1-17.

Nguye, H.H. & Tran, H.V. *"Digital Society and Society 5.0: Urgent Issues for Digital Social Transformation in Vietnam,"* **Masyarakat, Kebudayaan & Politik,** 35, 1, 2022.

Ni, W., Hu, X., Ju, Y. & Wang, Q. *"Air Pollution and Indoor Work Efficiency: Evidence from Professional Basketball Players in China,"* **Journal of Cleaner Production,** 399, 2023: 136644.

Nimlyat, P.S., Inusa, Y.J. & Nanfel, P.K. *"A Literature Review of Indoor Air Quality and Sick Building Syndrome in Office Building Design Environment,"* **Green Building & Construction Economics,** 2023: 1-18.

Nimlyat, P.S., Salihu, B. & Wang, G.P. *"The Impact of Indoor Environmental Quality (IEQ) on Patients' Health and Comfort in Nigeria,"* **International Journal of Building Pathology and Adaptation,** 2022.

Niza, I.L., de Souza, M.P., da Luz, I.M. & Broday, E.E. *"Sick Building Syndrome and Its Impacts on Health, Well-Being and Productivity: A Systematic Literature Review,"* **Indoor and Built Environment,** 33, 2, 2024: 218-236.

Nja, C.O., Umali, C.U.B., Asuquo, E.E. & Orim, R.E. *"The Influence of Learning Styles on Academic Performance among Science Education Undergraduates at the University of Calabar,"* **Educational Research and Reviews,** 14, 17, 2019: 618-624.

Njoku, H., Odugu, O. & Chibuike, N. *"Investigation of Indoor Thermal Comfort and Air Quality in Typical Student Residences,"* **Proceed-ings Paper,** 3, 2021.

Noor, S.N.A.M. & Ding, H.H. *"Indoor Environment Quality (IEQ): Temperature and Indoor Air Quality (IAQ) Factors toward Occupants Satisfaction,"* In IOP Conference Series: **Materials Science and Engineering,** 864, 1, 2020: 012012.

Obi, N.I., Obi, J.S.C., Ibem, E.O., Nwalusi, D.M. & Okeke, O.F. *"Noise Pollution in Urban Residential Environments: Evidence from Students' Hostels in Awka, Nigeria,"* **Journal of Settlements and Spatial Planning,** 12, 1, 2021: 51-62

Ochoa-Aviles, A., Parra-Ullauri, A., Jaramillo-Torres, M.J., Escandon, S., Parra-Ullauri, M., Mejia, D., Ochoa-Aviles, C. & Rodas-Espinoza, C. *"Indoor Environmental Quality in Pre-school Buildings in an Andean City in Ecuador."* **Journal of Green Building,** 19, 1, 2024: 177-204.

Ode, O.M., Okolie, K.C., Ezeokoli, F.O. & Obodoh, D.A. *"An Examination of sources of Indoor Air Contaminants in the Students' hostel Rooms in Nnamdi Azikiwe University, Awka-Anambra State."* **Tropical Built Environment Journal,** 9, 2, 2023.

Offor, J.N. *"Investigation of the Influence of Natural Ventilation on Indoor Comfort of Occupants of Public Hospital Wards within the Hot-Humid Climates,"* **Irish International Journal of Engineering and Applied Sciences,** 6, 2, 2022.

Oguntunde, D.O., Adedire, F.M., Alagbe, O.A. & Anthony, C.O. *"Relationship between Indoor Thermal Conditions, Sleep Quality, Health and Performance in a Warm-Humid University's Students Hostel,"* **Archiculture,** 5, 1, 2023: 150-160.

Omole, O.A., Mbamali, I. & Abdulsalam, D. *"Comparison of Indoor Air Quality in Eateries within Zaria Metropolis,"* **International Journal of Atmospheric and Oceanic Sciences,** 4, 1, 2020: 1-6. doi: 10.11648/j.ijaos.20200401.11

Onifade, V. *"The Effects of Residential Environmental Factors on Residents' Housing Satisfaction in Ogun State, Nigeria,"* **Ghana Journal of Geography,** 13, 2, 2021.

Ooi, P.L., Goh, K.T., Phoon, M.H., Foo, S.C. & Yap, H.M. *"Epidemiology of Sick Building Syndrome and Risk Factors in Singapore,"* **Occup Environ Med,** 55, 2020:188–193.

Ormandy, D. & Ezratty, V. "*Housing, health, and the domestic environment, "In Clay's Handbook of Environmental Health",* **Routledge**, 2022: 490-515.

Orola, B.A. *"Seasonal Variations in Indoor Air Quality Parameters and Occupants Self-Reported Physical Health within a Warm Humid Climatic Environment,"* **Sustainable Buildings,** 5, 2, 2020: 1-30.

Pal, V.K. & Khwaja, H.A. *"Personal Exposure and Inhaled Dose Estimation of Air Pollutants during Travel between Albany, NY and Boston, MA."* **Atmosphere,** 13, 3, 2022: 445.

Pandey, J., Kumar, M., & Singh, S. *"Organizational Ethical Climate: Influence on Employee Meaning and Wellbeing,"* **Management Decision,** 2024.

Park, J.H., Lee, T.J., Park, M.J., Oh, H. & Jo, Y.M. *"Effects of Air Cleaners and School Characteristics on Classroom Concentrations of Particulate Matter in 34 Elementary Schools in Korea,"* **Building and Environment,** 167, 2020: 106437.

Perumal, S.R., Baharum, F. & Nawi, M.N.M. *"Addressing Visual Comfort Issues in Healthcare Facilities Using LED Lighting Technology: A Review on Daylighting Importance, Impact of Correlated Colour Temperature, Human Responses and Other Visual Comfort Parameters,"* **Journal of Advanced Research in Fluid Mechanics and Thermal Sciences,** 82, 2, 2021: 47-60.

Piasecki, M., Radziszewska-Zielina, E., Czerski, P., Fedorczak-Cisak, M., Zielina, M., Krzysciak, P., Kwasniewska-Sip, P. & Grzeskowiak, W. *"Implementation of The Indoor Environmental Quality (IEQ) Model for the Assessment of a Retrofitted Historical Masonry Building,"* **Energies,** 13, 22, 2020: 6051.

Polewczyk, I. & Jarosz, M. *"Teachers' and Students' Assessment of the Influence of School Rooms Acoustic Treatment on their Performance and Wellbeing,"* **Archives of Acoustics,** 45, 3, 2020: 401-417.

Porras Álvarez, S. *"Natural Light Influence on Intellectual Performance. A Case Study on University Students,"* **Sustainability,** 12, 10, 2020: 4167.

Porras-Salazar, J.A., Tartarini, F. & Schiavon, S. *"The Effect of Indoor Temperature on Work Performance of Fifty-Eight People in a Simulated Office Environment,"* **Building and Environment,** 263, 2024: 111813.

Pulimeno, M., Piscitelli, P., Colazzo, S., Colao, A. & Miani, A. *"Indoor Air Quality at School and Students' Performance: Recommendations of the UNESCO Chair on Health Education and Sustainable Development & the Italian Society of Environmental Medicine (SIMA),"* **Health Promotion Perspectives,** 10, 3, 2020: 169.

Putnam, T. *"The Art of Home-Making and the Design Industries. In Contemporary Art and the Home,"* **Routledge,** 2020: 75-92.

Quarta, S., Levante, A., García-Conesa, M.T., Lecciso, F., Scoditti, E., Carluccio, M.A., Calabriso, N., Damiano, F., Santarpino, G., Verri, T. & Pinto, P. *"Assessment of Subjective Well-Being in a Cohort of University Students and Staff Members: Association with Physical Activity and Outdoor Leisure Time during the COVID-19 Pandemic,"* **International Journal of Environmental Research and Public Health,** 19, 8, 2022: 4787.

Quesada-Molina, F. & Astudillo-Cordero, S. *"Indoor Environmental Quality Assessment Model for Houses,"* **Sustainability,** 15, 2, 2023: 1-18.

Radun, J., Lindberg, M., Lahti, A., Veermans, M., Alakoivu, R. & Hongisto, V. *"Pupils' Experience of Noise in Two Acoustically Different Classrooms,"* **Facilities,** 41, 15/16, 2023: 21-37.

Rahi, S. *"Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues and Instruments Development,"* **International Journal of Economics & Management Sciences,** 6, 2, 2017: 1-5.

Ramani, S., Könings, K.D., Ginsburg, S. & van der Vleuten, C.P. *"Meaningful Feedback through a Sociocultural Lens,"* **Medical Teacher,** 41, 12, 2019: 1342-1352.

Rance, G., Dowell, R.C. & Tomlin, D. "*The Effect of Classroom Environment on Literacy Development,"* **npj Science of Learning,** 8, 1, 2023: 9.

Realyvasquez-Vargas, A., Maldonado-Macías, A.A., Arredondo-Soto, K.C., Baez-Lopez, Y., Carrillo- Gutiérrez, T. & Hernández-Escobedo, G. *"The Impact of Environmental Factors on Academic Performance of University Students taking Online Classes during the COVID-19 Pandemic in Mexico,"* **Sustainability**, 12, 21, 2020: 9194.

Reynolds, K.A., Sommer, J., Mackenzie, C.S. & Koven, L. *"A Profile of Social Participation in a Nationally Representative Sample of Canadian Older Adults: Findings from the Canadian Longitudinal Study on Aging,"* **Canadian Journal on Aging/La Revue canadienne du vieillissement,** 41, 4, 2022: 505-513.

Reza, F. & Kojima, S. *"Thermal Comfort Investigation Based Design Considerations for the Tropical Studio Type Classroom,"* **Int. J. Sustain. Dev. Plan,** 15, 8, 2020: 1179-1185.

Rhee, J.H., Schermer, B., Han, G., Park, S.Y. & Lee, K.H. *"Effects of Nature on Restorative and Cognitive Benefits in Indoor Environment,"* **Scientific Reports,** 13, 1, 2023:13199.

Riratanaphong, C. & Chaiprasien, B. *"The Impact of Workplace Change of a Private Jet Company on Employee Satisfaction,"* **Facilities,** 38, 13/14, 2020: 943-960.

Riva, A., Rebecchi, A., Capolongo, S & Gola, M. *"Can Homes Affect Wellbeing? A Scooping Review among Housing Conditions, Indoor Environmental Quality, and Mental Health Outcomes,"* **International Journal of Environmental Research and Public Health,** 19, 23, 2022: 15975.

Roos, M.J., Snijders, B.M. & Keijsers, C.J. *"Incidence of Infection as the Underlying Cause for Hypothermia in Older Patients at the Emergency Department,"* **Journal of the American Geriatrics Society,** 2023.

Roumi, S., Zhang, F., Stewart, R.A. & Santamouris, M. *"Commercial Building Indoor Environmental Quality Models: A Critical Review,"* **Energy and Buildings**, 263, 2022: 112033

Ruozhu, Y.I.N., Leung, M.Y. & Yueran, L.I. *"A Preliminary Study of the Relationship between Built Environment of Open Space and Cognitive Health of Older People."* **Journal of Contemporary Urban Affairs,** 7, 2, 2023: 144-155.

Saba-Sadeghpour, F. *"Effects of Physical Environmental Design Attributes on Psychological Well-being of College Students in University Dormitory during the Covid-19 Pandemic Period,"* **Architectural Research,** *24,* 4, 2022: 105-111.

Sadafi, N. & Azhdari, L. *"Investigating the Impact of Nature in Designing Cultural Environments for Children,"* **International Journal of Engineering and Management Sciences,** 5, 1, 2020: 244-256.

Sadick, A.M., Kpamma, Z.E. & Agyefi-Mensah, S. *"Impact of Indoor Environmental Quality on Job Satisfaction and Self-Reported Productivity of University Employees in a Tropical African Climate,"* **Building and Environment,** 181, 2020: 107-102.

Sadrizadeh, S., Yao, R., Yuan, F., Awbi, H., Bahnfleth, W., Bi, Y., Cao, G., Croitoru, C., de Dear, R., Haghighat, F. & Kumar, P. *"Indoor Air Quality and Health in Schools: A Critical Review for Developing the Roadmap for the Future School Environment,"* **Journal of Building Engineering,** 2022: 104908.

Saini, J., Dutta, M. & Marques, G. *"A Comprehensive Review on Indoor Air Quality Monitoring Systems for Enhanced Public Health,"* **Sustainable Environment Research,** 30, 1, 2020: 1-12.

Sakellaris, I., Saraga, D., Mandin, C., de Kluizenaar, Y., Fossati, S., Spinazze, A., Cattaneo, A., Mihucz, V., Szigeti, T., de Oliveira Fernandes, E. & Kalimeri, K. *"Association of Subjective Health Symptoms with Indoor Air Quality in European Office Buildings: The OFFICAIR Project,"* **Indoor Air,** 31, 2, 2021: 426-439.

Samuel, I.R. & Ukpoh, A. *"Influence of Teachers' Attitude towards Practical Chemistry on Senior Secondary Schools Students' Interest and Achievement in Nasarawa State, Nigeria,"* **International Journal of Innovative Psychology and Social Development**, 9, 3, 2021: 139-149.

Sanchez-Soberon, F., Rovira, J., Sierra, J., Mari, M., Domingo, J.L. & Schuhmacher, M. *"Seasonal Characterization and Dosimetry-Assisted Risk Assessment of Indoor Particulate Matter (PM10-2.5, PM2. 5-0.25, and PM0. 25) Collected in Different Schools,"* **Environmental Research,** 175, 2019: 287-296.

Sansaniwal, S.K., Mathur, J. & Mathur, S. *"Review of Practices for Human Thermal Comfort in Buildings:Present and Future Perspectives,"* **International Journal of Ambient Energy,** 43, 1, 2022: 2097-2123.

Sarkhosh, M., Najafpoor, A.A., Alidadi, H., Shamsara, J., Amiri, H., Andrea, T. & Kariminejad, F. *"Indoor Air Quality Associations with Sick Building Syndrome: An Application of Decision Tree Technology,"* **Building and Environment,** 188, 2021: 107446.

Sayan, H.E. & Dulger, S. *"Evaluation of the Relationship between Sick Building Syndrome Complaints among Hospital Employees and Indoor Environmental Quality,"* **La Medicina del lavoro,** 112, 2, 2021:153.

Schweiker, M., Ampatzi, E., Andargie, M.S., Andersen, R.K., Azar, E., Barthelmes, V.M., Berger, C., Bourikas, L., Carlucci, S., Chinazzo, G. & Edappilly, L.P. *"Review of Multi-Domain Approaches to Indoor Environmental Perception and Behaviour,"* **Building and Environment,** 176, 2020: 106804.

Shafavi, N.S., Zomorodian, Z.S., Tahsildoost, M. & Javadi, M. *"Occupants Visual Comfort Assessments: A Review of Field Studies and Lab Experiments,"* **Solar Energy**, 208, 2020: 249-274.

Shao, Z., Bi, J., Yang, J. & Ma, Z. "Indoor PM2. 5, *Home Environmental Factors and Lifestyles are Related to Sick Building Syndrome among Residents in Nanjing, China,"* **Building and Environment,** 235, 2023: 110204.

Sharma, A. & Kumar, A. *"Adaptive Thermal Comfort of Residential Buildings in the Composite Climatic Region of India: A Field Study,"* **Architectural Engineering and Design Management,** 2023: 1-22.

Shen, X., Zhang, H., Li, Y., Qu, K., Zhao, L., Kong, G. & Jia, W. *"Building a Satisfactory Indoor Environment for Healthcare Facility Occupants: A Literature Review,"* **Building and Environment,** 2022: 109861.

Shen, Z., Yang, X., Liu, C. & Li, J. *"Assessment of Indoor Environmental Quality in Budget Hotels Using Text-Mining Method: Case Study of Top Five Brands in China,"* **Sustainability,** 13, 8, 2021: 4490.

Shi, X. "*Environmental Health Perspectives for Low-and Middle-Income Countries,"* **Global Health Journal,** 6, 1, 2022: 35-37.

Shim, I.K., Kim, J., Won, S.R., Hwang, E.S., Lee, Y., Park, S., Ryu, J. & Lee, J. *"Prevalence of Sick Building Syndrome Symptoms and Subjective–Objective Indoor Air Quality of Stores in Underground Shopping Districts of Korea,"* **Building and Environment,** 228, 2023: 109882.

Sholanke, A.B., Faleti, M.O. & Ukaigwe, K.C. *"Users' Perception of Comfort Experienced in Academic Buildings of Selected Universities in Ogun State, Nigeria,"* In IOP Conference Series: **Earth and Environmental Science**, 1054, 1, 2022:.012026.

Shrestha, M., Rijal, H.B., Kayo, G. & Shukuya, M. *"A Field Investigation on Adaptive Thermal Comfort in School Buildings in the Temperate Climatic Region of Nepal,"* **Building and Environment,** 190, 2021: 107523.

Sikram, T., Ichinose, M. & Sasaki, R. *"Assessment of Thermal Comfort and Building-Related Symptoms in Air-Conditioned Offices in Tropical Regions: A Case Study in Singapore and Thailand,"* **Frontiers in Built Environment,** 6, 2020: 567787.

Singh, M., Kumar, P., Gupta, R. & Sharma, P. *"Impact of Window Type on Indoor Environmental Quality and Students' Wellbeing in Hostel Rooms,"* **Journal of Building Engineering,** 29, 2020: 101934.

Singh, M., Sharma, P., Zheng, X., Liu, Y., Wang, H., Hamed, A., Kim, J. & Lee, Y. *"The Impact of IEQ Conditions on Students' Wellbeing: A Systematic Review,"* **Journal of Building Engineering,** 29, 2020: 101934.

Singh, P., Arora, R. & Goyal, R. *"Impact of Lighting on Performance of Students in Delhi Schools,"* **In Indoor Environmental Quality:** Select Proceedings of the 1st ACIEQ, 2020: 95-108.

Stieb, D.M., Evans, G.J., To, T.M., Lakey, P.S. Shiraiwa, M., Hatzopoulou, M., Laura, M., Brook, J.F., Burnett, R.T. & Weichenthal, S.A. *"Within-City Variation in Reactive Oxygen Species from Fine Particle Air Pollution and COVID-19,"* **American Journal of Respiratory and Critical Care Medicine**, 204, 2, 2021: 168-177.

Subhashini, S., Kesavaperumal, T. & Noguchi, M. *"An Adaptive Thermal Comfort Model for Naturally Ventilated Classrooms of Technical Institutions in Madurai,"* **Open House International,** 46, 4, 2021: 682-696.

Sudarsanam, N. & Kannamma, D. *"Investigation of Summertime Thermal Comfort at the Residences of Elderly People in the Warm and Humid Climate of India,"* **Energy and Buildings,** 291, 2023: 113151.

Sullivan, W.C. & Li, D. *"Nature and Attention,"* **Nature and Psychology: Biological, Cognitive, Developmental, and Social Pathways to Well-Being,** 2021: 7-30.

Sun, C., Han, Y., Luo, L. & Sun, H. *"Effects of Air Temperature on Cognitive Work Performance of Acclimatized People in Severely Cold Region in China,"* **Indoor and Built Environment,** 30, 6, 2021: 816-837.

Sun, L. & Wallace, L.A. *"Residential Cooking and Use of Kitchen Ventilation: The Impact on Exposure,"* **Journal of the Air & Waste Management Association,** 71, 7, 2021: 830-843.

Surucu, L. & Maslakçi, A. "*Validity and Reliability in Quantitative Research,*" **Business & Management Studies: An International Journal,** 8, 3, 2020: 2694-2726.

Suzuki, N., Nakayama, Y., Nakaoka, H., Takaguchi, K., Tsumura, K., Hanazato, M. & Mori, C. *"Risk Factors for the Onset of Sick Building Syndrome: A Cross-Sectional Survey of Housing and Health in Japan,"* **Building and Environment,** 202, 2021: 107976.

Tadese, M., Yeshaneh, A. & Mulu, G.B. *"Determinants of Good Academic Performance among University Students in Ethiopia: A Cross-Sectional Study,"* **BMC Medical Education,** 22, 1, 2022: 1-9.

Taherdoost, H. *"Data Collection Methods and Tools for Research: A Step-by-Step Guide to Choose Data Collection Technique for Academic and Business Research Projects,"* **International Journal of Academic Research in Management (IJARM),** 10, 1, 2021: 10-38.

Talukdar, M.S.J., Talukdar, T.H., Singh, M.K., Baten, M.A. & Hossen, M.S. *"Status of Thermal Comfort in Naturally Ventilated University Classrooms of Bangladesh in Hot and Humid Summer Season,"* **Journal of Building Engineering,** 32, 2020: 101700.

Tang, H., Ding, Y. & Singer, B.C. *"Post-Occupancy Evaluation of Indoor Environmental Quality in Ten Non-Residential Buildings in Chongqing, China,"* **Journal of Building Engineering,** 32, 2020: 101-649. https://doi.org/ 10.1016/j.jobe.2020.101649

Tang, H., Liu, X., Geng, Y., Lin, B. & Ding, Y. *"Assessing the Perception of Overall Indoor Environmental Quality: Model Validation and Interpretation,"* **Energy and Buildings,** 259, 2022: 111870.

Taylor, E.M., Robertson, N., Lightfoot, C.J., Smith, A.C. & Jones, C.R. *"Nature-Based Interventions for Psychological Wellbeing in Long-Term Conditions: A Systematic Review,"* **International Journal of Environmental Research and Public Health,** 19, 6, 2022: 3214.

Taylor, S.P. "*A Realist Philosophical Approach for Housing Research: Critical Realism,*" **International Journal of Housing and Human Settlement Planning,** 6, 2, 2020: 1-20.

Tentama, F. & Abdillah, M.H. *"Student Employability Examined from Academic Achievement and Self-Concept,"* **International Journal of Evaluation and Research in Education,** 8, 2, 2019: 243-248.

Tham, S., Thompson, R., Landeg, O., Murray, K.A. & Waite, T. *"Indoor Temperature and Health: A Global Systematic Review,"* **Public Health,** 179, 2020: 9-17.

Thangaswamy, G. C., Arulappan, J., Anumanthan, S. & Jayapal, S. K. *"Trends and Determinants of Mental Health during COVID-19 Pandemic: Implications and Strategies to Overcome the Mental Health Issues: A Rapid Review from 2019-2020,"* **International Journal of Nutrition, Pharmacology, Neurological Diseases,** 11, 1, 2021: 1-6.

Thomas, F., Kain, T. & Monica, G.B. *"27 The Spiritual Dimension of Health,"* **One Health: The Theory and Practice of Integrated Health Approaches,** 2020: 356.

Thompson, R., Smith, R.B., Karim, Y.B., Shen, C., Drummond, K., Teng, C. & Toledano, M.B. *"Noise Pollution and Human Cognition: An Updated Systematic Review and Meta-Analysis of Recent Evidence."* **Environment International** 158, 2022: 106905.

Toyinbo, O. *"Indoor Environmental Quality, Pupils' Health, and Academic Performance: A Literature Review,"* **Buildings,** 13, 9, 2023: 2172.

Tran, V.V., Park, D. & Lee, Y.C. *"Indoor Air Pollution, Related Human Diseases, and Recent Trends in the Control and Improvement of Indoor Air Quality,"* **International Journal of Environmental Research and Public Health,** 17, 8, 2020: 2927.

Tsantaki, E., Smyrnakis, E., Constantinidis, T.C. & Benos, A. *"Indoor Air Quality and Sick Building Syndrome in a University Setting: A Case Study in Greece,"* **International Journal of Environmental Health Research,** 32, 3, 2022: 595-615.

Uotila, U. & Saari, A. *"Determining Ventilation Strategies to Relieve Health Symptoms among School Occupants,"* **Facilities,** 41, 15/16, 2023: 1-20.

Vardoulakis, S., Giagloglou, E., Steinle, S., Davis, A., Sleeuwenhoek, A., Galea, K.S., Dixon, K. & Crawford, J.O. *"Indoor Exposure to Selected Air Pollutants in the Home Environment: A Systematic Review,"* **International Journal of Environmental Research and Public Health**, 17, 23, 2020: 8972.

Vassella, C.C., Koch, J., Henzi, A., Jordan, A., Waeber, R., Iannaccone, R. & Charrière, R. *"From Spontaneous to Strategic Natural Window Ventilation: Improving Indoor Air Quality in Swiss Schools,"* **International Journal of Hygiene and Environmental Health,** 234, 2021: 113746

Wan, K., Feng, Z., Hajat, S. & Doherty, R.M. *"Temperature-Related Mortality and Associated Vulnerabilities: Evidence from Scotland Using Extended Time-Series Datasets,"* **Environmental Health,** 21, 1, 2022: 1-14.

Wang, C., Zhang, F., Wang, J., Doyle, J.K., Hancock, P.A., Mak, C.M. & Liu, S. *"How Indoor Environmental Quality Affects Occupants' Cognitive Functions: A Systematic Review,"* **Building and Environment,** 193, 2021: 107647.

Wang, D., Song, C., Wang, Y., Xu, Y., Liu, Y. & Liu, J. *"Experimental Investigation of* *the Potential Influence of Indoor Air Velocity on Students' Learning Performance in Summer Conditions,"* **Energy and Buildings,** 219, 2020: 110015.

Wang, J., Janson, C., Gislason, T., Gunnbjörnsdottir, M., Jogi, R., Orru, H. & Norbäck, D. *"Volatile Organic Compounds (VOC) in Homes Associated with Asthma and Lung Function among Adults in Northern Europe,"* **Environmental Pollution,** 321, 2023: 121103.

Wankasi, H.I., Aluye-Benibo, D., Amakoromo, T., Beredugo, L.I. & Ere, B.E. *"Environmental Factors that Affect Academic Performance of Public Secondary School Students: A Cross Sectional Study,"* **Journal of Medical and Dental Science Research,** 9, 5, 2022: 18-30.

Wargocki, P., Porras-Salazar, J.A., Contreras-Espinoza, S. & Bahnfleth, W. *"The Relationships between Classroom Air Quality and Children's Performance in School,"* **Building and Environment,** 173, 106749, 2020: 1-20.

Waseem, T. & Aslam, F. *"Educational Learning Theories and their Implications in Modern Instructional Designs,"* **Health Professions Educator Journal,** 3, 2, 2020: 25-31.

Wen, Y., Leng, J., Shen, X., Han, G., Sun, L. & Yu, F. *"Environmental and Health Effects of Ventilation in Subway Stations: A Literature Review,"* **International Journal of Environmental Research and Public Health,** 17, 3, 2020: 1084.

Whitlock, J., Kingan, M., Dykes, C., Gronert, R., Cliff, C. & Ackley, A. *"Designing Schools in New Zealand (DSNZ): Designing Quality Learning Spaces (DQLS) Acoustics. Version 3.0, November 2020."* **The Journal of the Acoustical Society of America,** 154, 4 2020: A214-A214.

Wijnia, L., Noordzij, G., Arends, L.R., Rikers, R.M. & Loyens, S.M. *"The Effects of Problem-Based, Project-Based, and Case-Based Learning on Students' Motivation: A Meta-Analysis,"* **Educational Psychology Review,** 36, 1, 2024: 29.

Wolkoff, P. *"Indoor Air Humidity Revisited: Impact on Acute Symptoms, Work Productivity, and Risk of Influenza and COVID-19 Infection,"* **International Journal of Hygiene and Environmental Health,** 256, 2024: 114313.

Wolkoff, P., Azuma, K. & Carrer, P. *"Health, Work Performance, and Risk of Infection in Office-like Environments: The Role of Indoor Temperature, Air Humidity, and Ventilation,"* **International Journal of Hygiene and Environmental Health**, 233, 2021: 113709.

Woo, J., Rajagopalan, P., Francis, M. & Garnawat, P. *"An Indoor Environmental Quality Assessment of Office Spaces at an Urban Australian University,"* **Building Research and Information,** 49, 8, 2021: 842-858.

Wood, S.G., Handy, A.E., Roberts, K. & Burridge, H.C. *"Assessing Classroom*

*Ventilation Rates using $CO_2$ Data from a Nationwide Study of UK Schools and Identifying School-wide Correlation Factors,"* **Developments in the Built Environment,** 2024: 100520.

Xiao, Y., Becerik-Gerber, B., Lucas, G. & Roll, S.C. *"Impacts of Working from Home during COVID-19 Pandemic on Physical and Mental Well-Being of Office Workstation Users,"* **Journal of Occupational and Environmental Medicine,** 63, 3, 2021: 181.

Yadeta, C., Indraganti, M., Alemayehu, E. & Tucho, G.T. *"An Investigation of Human Thermal Comfort and Adaptation in Naturally Ventilated Residential Buildings and Its Implication for Energy Use in Tropical Climates of Ethiopia,"* **Science and Technology for the Built Environment,** 28, 7, 2022: 896-915.

Yaman, G.O., Varolguneş, F.K. & Çulun, P. *"Investigation of Thermal Comfort in University Offices: The Case of the Bingol University,"* **Civil Engineering and Architecture,** 9, 7, 2021: 2441-2451.

Yang, B., Liu, P., Liu, Y., Jin, D. & Wang, F. *"Assessment of Thermal Comfort and Air Quality of Room Conditions by Impinging Jet Ventilation Integrated with Ductless Personalized Ventilation,"* **Sustainability**, 14, 19, 2022: 12526.

Yang, L., Zhao, S., Gao, S., Zhang, H., Arens, E. & Zhai, Y. *"Gender Differences in Metabolic Rates and Thermal Comfort in Sedentary Young Males and Females at Various Temperatures,"* **Energy and Buildings**, 251, 2021: 111360.

Yang, W. & Jeon, J.Y. *"Effects of Correlated Colour Temperature of LED Light On Visual Sensation, Perception, And Cognitive Performance In A Classroom Lighting Environment,"* **Sustainability,** 12, 10, 2020: 4051.

Yang, Z., Zhang, W., Qin, M. & Liu, H. *"Comparative Study of Indoor Thermal Environment and Human Thermal Comfort in Residential Buildings among Cities, Towns, and Rural Areas in Arid Regions of China,"* **Energy and Buildings**, 273, 2022: 112373.

Yao, R., Zhang, S., Du, C., Schweiker, M., Hodder, S., Olesen, B.W., Toftum, J., d'Ambrosio, F.R., Gebhardt, H., Zhou, S. & Yuan, F. *"Evolution and Performance Analysis of Adaptive Thermal Comfort Models–A Comprehensive Literature Review,"* **Building and Environment,** 217, 2022: 109020.

Yuan, F., Yao, R., Sadrizadeh, S., Li, B., Cao, G., Zhang, S., Zhou, S., Liu, H., Bogdan, A., Croitoru, C. & Melikov, A. "*Thermal Comfort in Hospital Buildings–A Literature Review,"* **Journal of Building Engineering,** 45, 2022: 103463.

Yussuf, S.M., Dahir, G. & Salad, A.M. *"Sick Building Syndrome and Its Associated Factors among Adult People Living in Hodan District Moqadishu Somalia,"* **Age,** 18, 28, 2023:129.

Zakaria, I.B. & Mahyuddin, N. *"An Overview of Indoor Air Pollution in the Malaysian*

*Kindergarten Environment,"* *In IOP Conference Series:* **Earth and Environmental Science***,* 1013, 1, 2022: 012005.

Zakaria, I.B. & Mahyuddin, N. *"Indoor Air Quality (IAQ) in Malaysian Kindergarten: A Thematic Review,"* **International Journal of Real Estate Studies,** 16, S1, 2022: 47-55.

Zender-Świercz, E. *"Review of IAQ in Premises Equipped with Façade–Ventilation Systems,"* **Atmosphere,** 12, 2, 2021: 220.

Zhang, D., Ding, E. & Bluyssen, P.M. *"Guidance to Assess Ventilation Performance of a Classroom Based on $CO_2$ Monitoring,"* **Indoor and Built Environment,** 31, 4, 2022: 1107-1126.

Zhang, H. & Srinivasan, R. *"A Systematic Review of Air Quality Sensors, Guidelines, and Measurement Studies for Indoor Air Quality Management,"* **Sustainability,** 12, 21, 2020: 9045.

Zhang, L. & Ma, H. *"The Effects of Environmental Noise on Children's Cognitive Performance and Annoyance,"* **Applied Acoustics,** 198, 2022: 108995.

Zhang, L., Ou, C., Magana-Arachchi, D., Vithanage, M., Vanka, K.S., Palanisami, T., Masakorala, K., Wijesekara, H., Yan, Y., Bolan, N. & Kirkham, M.B. *"Indoor Particulate Matter in Urban Households: Sources, Pathways, Characteristics, Health Effects, and Exposure Mitigation,"* **International Journal of Environmental Research and Public Health,** 18, 21, 2021: 11055.

Zhao, W., Kilpeläinen, S., Kosonen, R., Jokisalo, J., Lestinen, S., Wu Y. & Mustakallio, P. *"Human Response to Thermal Environment and Perceived Air Quality in an Office with Individually Controlled Convective and Radiant Cooling Systems,"* **Building and Environment,** 195, 2021: 107736.

Zomorodian, Z.S., Tahsildoost, M. & Hafezi, M. *"Thermal Comfort in Educational Buildings: A Review Article,"* **Renewable and Sustainable Energy Reviews,** 59, 2016: 895-906.

Zou, W. C., Houghton, J. D. & Li, J. J. *"Workplace Spirituality as a means of Enhancing Service Employee Wellbeing through Emotional Labor Strategy Choice,"* **Current Psychology**, 41, 8, 2022: 5546-5561.

Zubir, N., Jalaludin, J. & Rasdi, I. *"Indoor Air Quality and Psychosocial Factors Related to Sick Building Syndrome among Office Workers in New and Old Buildings of a Public University in Klang Valley, Malaysia,"* **Malaysian Journal of Medicine & Health Sciences,** 18, 2022.

Zumelzu, A., & Herrmann-Lunecke, M. G. *"Mental Wellbeing and the Influence of Place: Conceptual Approaches for the Built Environment for Planning Healthy and Walkable Cities,"* **Sustainability,** *13,* 11, 2021: 6395.

**Periodical Article**

Adaji, M.U., Adekunle, T. & Watkins, R. *"Overheating and Passive Cooling Intervention on Low-Income Residential Houses in Abuja, Nigeria,"* In Proceedings of the 11th Windsor Conference, UK, 2020.

Albelda-Estellés Ness, M.C. *"Indoor Relative Humidity: Relevance for Health, Comfort, and Choice of Ventilation System,"* In Proceedings of 3rd Valencia International Biennial of Research in Architecture. Changing priorities. Valencia. 2022: 218-228. https://doi.org/10.4995/VIBRArch2022.2022.15237

Asaju, O., Alagbe, O. & Adetona, O. *"Investigation of Indoor Environmental Quality of Lecture Rooms on Students' Comfort in Selected Polytechnics, Lagos, Nigeria" In Towards a Sustainable Construction Industry: The Role of Innovation and Digitalisation".* Proceedings of 12th Construction Industry Development Board (CIDB) Postgraduate Research Conference Cham: Springer International Publishing, 2023, 54-63.

Chen, J., Hu, H., Wu, H., Jiang, Y. & Wang, C. *"Learning the Best Pooling Strategy for Visual Semantic Embedding",* In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition, 2021:15789-15798).

Kumar, A., Kumar, A. & Jain, K. *"Apps for Integrating Daylight with Artificial Lighting for Improving Building Energy Efficiency during Daytime in All Climates of India,"* Extracts from the Register of Copyrights, Copyright Office GOI, ROC-SW-12111/2019, 2019.

Martins, L.A., Williamson, T., Bennetts, H., Zuo, J., Visvanathan, R., Hansen, A., Pisaniello, D., Hoof, J. & Soebarto, V. *"Individualising Thermal Comfort Models for Older People: The Effects of Personal Characteristics on Comfort and Wellbeing","* In 2020 Windsor Conference, 2020:187-199.

Mogas-Recalde, J. & Palau, R. *"Classroom Lighting and Its Effect on Student Learning and Performance towards Smarter Conditions: In Ludic, Co-Design and Tools Supporting Smart Learning Ecosystems and Smart Education",* Proceedings of the 5th International Conference on Smart Learning Ecosystems and Regional Development, 2021: 3-12.

Pacitto, A., Stabile, L., Frattolillo, A., Mikszewski, A., Morawska, L. & Buonanno, G. *"Ventilation Strategies to Minimize the Airborne Virus Transmission in Indoor Environments."* In Proceedings of the 17th International Healthy Buildings Conference, SINTEF, 2021: 369-378.

Van Reenen, C. and Manley, D. "*Classroom Acoustics: Mainstreaming and Application of Standards"* In Proceedings of Meetings on Acoustics, AIP Publishing, 51, 1, 2023.

## Thesis/Dissertation

Ackley, A. *"Measuring Indoor Environmental Quality (IEQ) in a National School Property Portfolio"* Doctoral dissertation, Open Access Te Herenga Waka-Victoria University of Wellington, 2021

Andargie, M.S. "*Evaluating the Acoustic Performance of Multi-Unit Residential Buildings and the Associated Effects of Noise Exposure on Occupants' Comfort*," PhD Dissertation, University of Toronto, Canada, 2022.

Aransiola, M.J. "*Perceived Influence of Classroom Management Techniques on the Academic Performance of Business Studies Students in Secondary Schools in Kwara State, Nigeria,"* Master's Thesis, Kwara State University Nigeria, 2020.

Dickard, K. E. *"Who Puts the "Support" in Supportive Housing? The Impact of Housing Staff on Resident's Well-Being, and the Potential Moderating Role of Self-Determination,"* Master's Thesis, Portland State University, 2023.

Dokmeci, K. "*Investigation of Daylight in University Campus Buildings: İhsan Doğramaci Bilkent University and Mersin University,*" Master's thesis, Middle East Technical University, 2023.

Ejiga, A.E. "*Assessment of Thermal Comfort in Some Selected Lecture Rooms in Gidan-Kwano Campus,"* PhD Dissertation, Federal University of Technology Minna, 2023.

Joseph, V.B. "*Affect and the Workplace Built Environment,"* Doctoral Dissertation, University of Warwick, 2020

Kabirikopaei, A. *"A Data-Driven study on the Association of Classrooms' Indoor Air Quality, Thermal Environment, and Students' Academic Performance,"* Doctoral Dissertation, The University of Nebraska-Lincoln, 2021.

Narubayeva, S. "*Evaluation of Indoor Environmental Quality in Sagkeeng Junior School*," Master's Thesis, University of Manitoba Winnipeg, Manitoba, 2021).

Recker, M.L. "*Social and Emotional Learning Defined through Exploration of Albert Bandura's Social Cognitive Theory and Abraham Maslow's Hierarchy of Needs: A Document Analysis of Ohio's K-12 Social and Emotional Learning Standards and Theory Alignment,"* Doctoral Dissertation, University of Findlay**,** 2023.

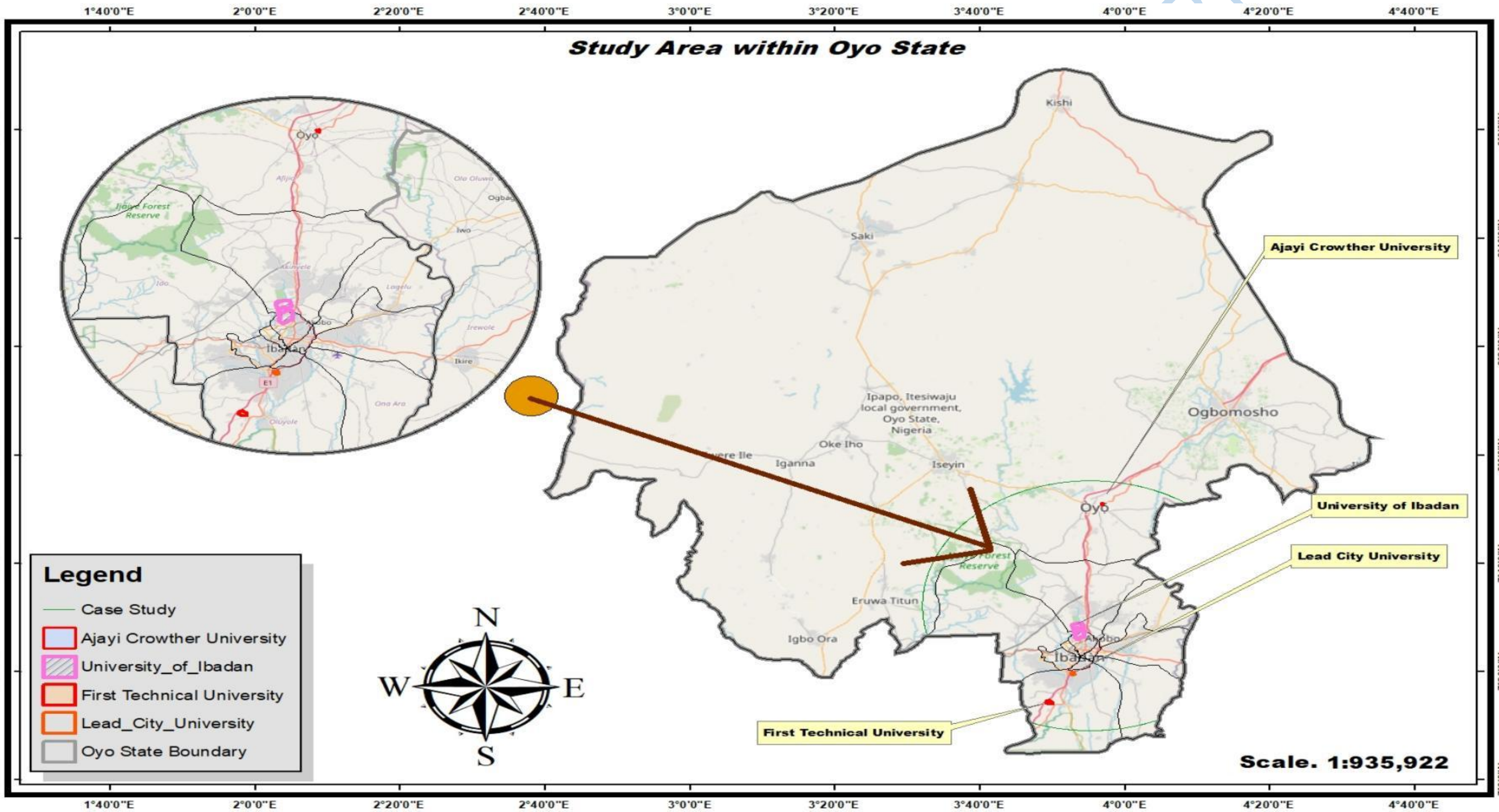
Swangsoonthonwes, P.I.L.A.S. & Kesornthong, S. *"Sick Building Syndrome in a University Hospital in Thailand"* Doctoral dissertation, Thammasat University, 2021.

Yuki, I. "*The Effect of Survey Scale Sizes on How People Assess the Effect of the Built Environment on their Work Performance."* PhD Dissertation, Open Access Te Herenga Waka-Victoria University of Wellington, 2020).

**Website**

Nenge, K. *Which is the largest city in Africa: Lagos vs. Ibadan city,* Legit. ng-Nigeria news, 2021. https://www.legit.ng/1212538-is-ibadan-largest-city-africa.html

## Appendix I




**Sources:** Researcher's Fieldwork, 2024

**Appendix II**

Department of Architecture

Lead City University, Ibadan.

**Evaluation of Hostel Rooms' Indoor Environmental Quality and its effects on Students' Wellbeing in Selected Universities in Oyo State, Nigeria**

Dear Respondents,

***Indoor Environmental Quality (IEQ) is a quality of building's environment in compliance to the occupants' health, productivity and wellbeing. It is also an acceptable levels of comforts benefitted from thermal, lighting/visual, acoustic and Indoor Air Quality (IAQ)***

This questionnaire is designed to collect information on the evaluation of Indoor Environmental Quality components of hostel rooms and its effect on students' wellbeing in selected Universities, Oyo State, Nigeria. You are kindly implored to provide appropriate answers in response to each question. Be rest assured that the information provided will be treated confidentially and used only for academic purpose.

For any information, contact:

**Name of Researcher:** Oguntunde, David Olaolu

**Mobile Phone number/Whatsapp number:** +234 805 422 4358.

**E-mail:** oguntunde.david@lcu.edu.ng

Thanks for your time and cooperation.

**Name of the Institution**: ……………………………………………………………..

**Name of Hostel**: ………………………………………………………………………

**Instruction:** Please, answer each question as completely and clearly as possible by ticking ( *) appropriately in the boxes provided. Some questions may require you to tick one answer only while others may request you to tick more than one.

**PART A: Respondent's Socio-Economic Information.**

1. **Age:** (a) Below 18 ( ); (b) 18-20 ( ); (c) 21-23 ( ); (d) 24-26 ( ); (e) 27 and above ( )

2. **Gender:** (a) Female ( ); (b) Male ( ); (c) Prefer not to say ( )

3. **Level of study:** (a) 200 ( ); (b) 300 ( ); (c) 400 ( ); (d) 500 ( ); (e) M.Sc. I ( ); (f) M.Sc. II ( ).

4. **Weight (in Kg):** (a) 40 and below ( ); (b) 41-50 ( ); (c) 51-60 ( ); (d) 61-70 ( ); (e) 71-80 ( );
(f) 81-90 ( ); (f) 91-100 ( ); (g) 100 and above ( ).

5. **Number of occupants in hostel room:** (a) 1-2 students ( ); (b) 3-4 students ( ); (c) 5-6 students ( );
(d) 7-8 students ( ); (e) More than 8 students ( ).

6. **Period of Occupancy:** (a) 1-2 months ( ); (b) 3-4 months ( ); (c) 5-6 months ( ); (d) 7-8 months ( );
(e) 9-10 months ( ); (f) 11 months and above ( ).

7. **Time of the day mostly spent in Hostel room per day:**
(a) Morning: 5:00am -11:59am ( ); (b) Afternoon: 12noon – 4:59pm ( ); (c) Evening/Night: 5:00pm – 11:59pm ( ).

8. **Average duration of time mostly spent in Hostel room per day:**
(a) 3-5 hrs ( ); (b) 6–8 hrs ( ); (c) 9–11 hrs ( ); (d) 12–14 hrs ( ); (e) 15-17 hrs ( ).

**PART B:** (This part is sub-divided into three (4) sections).

*The objective is to examine the satisfaction of the students with the Indoor Environmental Quality conditions in the hostel rooms of the selected universities.*

**SECTION I:** ***Assessment of Thermal Conditions in the Hostel Rooms.***

1. Please, rate your thermal comfort sensation in the hostel room. Please tick.

| **Timings** | **THERMAL SENSATIONS** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Cold** | **Cool** | **Slightly Cool** | **Neutral** | **Slightly warm** | **Warm** | **Hot** |
| **Morning** | | | | | | | |
| **Afternoon** | | | | | | | |
| **Night** | | | | | | | |

2. How do you prefer your hostel room temperature to be? Please tick.

| Timings | THERMAL PREFERENCES (The preference may vary depending on the season) | | | | |
|---|---|---|---|---|---|
| | Much cooler | Cooler | No change | Warmer | Much warmer |
| Morning | | | | | |
| Afternoon | | | | | |
| Night | | | | | |

3. How will you rate the air quality in your room?

| Timings | SENSATION OF AIR MOVEMENT | | | | |
|---|---|---|---|---|---|
| | Excellent | Very Good | Good | Fair | Poor |
| Morning | | | | | |
| Afternoon | | | | | |
| Night | | | | | |

4. How do you feel the moisture in air/humidity in your room?

| Timings | SENSATION OF MOISTURE IN AIR (HUMIDITY) | | | | |
|---|---|---|---|---|---|
| | Dry | Slightly dry | No change | Slightly humid | Humid |
| Morning | | | | | |
| Afternoon | | | | | |
| Night | | | | | |

5. Please, assess the overall thermal comfort in your room.

(a) Very-Uncomfortable ( ); (b) Slightly- Uncomfortable ( ); (c) Neutral ( ); (d) Slightly-Comfortable ( ); (e) Very-Comfortable ( ).

**SECTION II:** ***Assessment of Indoor Air Quality in the hostel rooms.***

1. How often do you open the windows in your hostel room?

(a)Never ( ); (b) Rarely ( ); (c) Sometimes ( ); (d) Often ( ); (e) Always ( ).

2. How smelly is the hostel indoor air?

(a) Extremely smelly ( ); (b) Moderately smelly ( ); (c) Somewhat smelly ( ); (d) Slightly smelly ( ); (e) Not at all smelly ( ).

3. How dusty is the air entering into the room?

(a)Extremely dusty ( ); (b) Moderately dusty ( ); (c) Somewhat dusty ( ); (d) Slightly dusty ( ); (e) Not at all dusty ( ).

4. How stuffy is the air quality in your room?

(a)Very stuffy ( ); (b) Stuffy ( ); (c) Neutral ( ); (d) Fresh ( ); (e) Very Fresh ( ).

5. On average, how satisfied or dissatisfied are you with the air quality of your hostel room?

(a)Very dissatisfied ( ); (b) Slightly dissatisfied ( ); (c) Neutral ( ); (d) Slightly-satisfied ( ); (e) Very satisfied ( ).

**SECTION III:** ***Assessment of Acoustics/Noise in the Hostel Rooms.***

1. How satisfied are you with the sound/noise level in the hostel?

(a)Very dissatisfied ( ); (b) Slightly dissatisfied ( ); (c) Neutral ( ); (d) Slightly-satisfied ( ); (e) Very satisfied ( ).

2. How satisfied are you with the quality of speech communication between you and your room-mates in the hostel room?

(a)Very dissatisfied ( ); (b) Slightly dissatisfied ( ); (c) Neutral ( ); (d) Slightly-satisfied ( ); (e) Very satisfied ( ).

3. Does the noise in the hostel affect your ability to concentrate or study in your room?

(a)Yes ( ); (b) No ( ); (c) Neutral ( ).

**SECTION IV:** ***Assessment of Visual/Lighting in the Hostel Rooms.***

1. On average, how satisfied are you visually with reflection and glare in your hostel room?

(a)Very dissatisfied ( ); (b) Slightly dissatisfied ( ); (c) Neutral ( ); (d) Slightly-satisfied ( ); (e) Very satisfied ( ).

2. How often do you use natural lighting in your hostel room?

(a) Always (b) Often ( ); (c) Sometimes ( ); (d) Rarely ( ); (e) Never ( ).

3. On daily average, how many hours of natural lighting do you use in your hostel rooms?

(a) 1-4 hours (b) 5-8 hours ( ); (c) 9-12 hours ( ); (d) 13-16 hours ( ); (e) More than 16 hours ( ).

4. How often do you need to control or adjust natural lighting by yourself in the hostel room?

(a) Always (b) Often ( ); (c) Sometimes ( ); (d) Rarely ( ); (e) Never ( ).

5. How satisfied are you with the electrical/artificial lighting conditions in the hostel?

(a)Very dissatisfied ( ); (b) Slightly dissatisfied ( ); (c) Neutral ( ); (d) Slightly-satisfied ( ); (e) Very satisfied ( ).

6. On daily average, how long is the electrical/artificial lighting used in your room after daily academic activities?

(a) 1-2 hours (b) 3-4 hours ( ); (c) 5-6 hours ( ); (d) 7-8 hours ( ); (e) More than 8 hours(

7. Please, rate the level of artificial lighting sufficiency for reading ability in your room

(a)Very insufficient (b) Insufficient ( ); (c)Unsure ( ); (d)Sufficient ( ); (e)Very sufficient

8. Does the artificial lighting of your room affect your ability to study at night in the hostel?

(a)Yes ( ); (b) No ( ); (c) Neutral ( ).

9. How do you control or adjust natural/artificial lightings in your room? ***Please, tick more than one if applicable.***

(a) Window blinds or shades ( ); (b) Light dimmer ( ); (c) Light switch ( ); (d) Wall bracket light (e)None ( ).

10. How satisfied are you with the overall natural lighting conditions in the hostel?

(a)Very dissatisfied ( ); (b) Slightly dissatisfied ( ); (c) Neutral ( ); (d) Slightly-satisfied ( ); (e) Very satisfied ( ).

**PART C:** *The objective is to establish the impacts IEQ conditions on students' wellbeing in the hostel rooms of the selected universities*

1. To what extent is the Indoor Environmental Quality (IEQ) components affect your concentration to study in the hostel room?

(a) No effect (b) Minor effect ( ); (c) Neutral ( ); (d) Moderate effect ( ); (e) Major effect

2. How much is your wellbeing be affected by the following Indoor Environmental Quality (IEQ) components in the hostel room?

| | **Extremely Affected** | **Very Affected** | **Moderately Affected** | **Slightly Affected** | **Not at all Affected** |
|---|---|---|---|---|---|
| ***Thermal condition*** | | | | | |
| ***Indoor Air Quality*** | | | | | |
| ***Acoustic/Noise*** | | | | | |
| ***Visual/Lighting*** | | | | | |

3. Please, rate your sleep quality level in the hostel room.

(a)Poor ( ); (b) Fair ( ); (c) Good ( ); (d) Very good ( ); (e) Excellent ( ).

4. Rate your level of motivation to wake-up for daily academic activities every morning?

(a)Very low ( ); (b) Low ( ); (c) Neutral ( ); (d) High ( ); (e) Very high ( );

5. Does the existing indoor condition of the room affect your health status?

(a)Yes ( ); (b) No ( ); (c) Neutral ( ).

6. Please, indicate any Sick Building Symptom frequently perceived in your hostel indoor. *Please, tick more than one if applicable.*

(a) Headache ( ); (b) Dizziness ( ); (c) Fatique ( ); (d) Dry/Irritated skin ( ); (e) Irritated nose & throat ( ); (f)Irritated eyes ( ); (g)Asthma ( ); (h) Cold hands & feet ( ); (i)Coughing ( ); (j)Concentration difficulty( ).

7. Which of the following do you recognize as the source of poor indoor air quality in your room? (***Note: Tick more than one if applicable***).

| **Sources** | **Yes** | **No** | **Neutral** |
|---|---|---|---|
| Odour from New Furniture | | | |
| Smoking smell | | | |
| Electronic equipment such as computer, photocopier, printer etc | | | |
| Outdoor pollution like dust entering the building | | | |
| Cooking | | | |
| Chemical substances smell | | | |
| Visible signs of moisture damage | | | |
| Mold/cedar-like odour | | | |
| Paint smell | | | |
| Perfume and Air Fresheners smell | | | |
| Pesticide or Insecticide odour | | | |

8. Do any of the above sources of poor indoor air quality indicated in your hostel room affect your concentration and motivation to studying? (a)Yes ( ); (b) No ( ); (c) Neutral ( )

If the answer to the above is Yes, kindly indicate the source that affects your concentration and motivation to studying the most

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9. On average, how much does the noise from the following sources disturb you in the hostel?

| **SOURCES OF NOISE** | **Level of Noise Disturbance** | | | | |
|---|---|---|---|---|---|
| | **Very disturbing** | **Slightly disturbing** | **Neutral** | **Slightly un-disturbing** | **Very un-disturbing** |
| ***Noise from Mechanical system (HVAC, Fan etc)*** | | | | | |
| ***Noise from Indoor (Instrumentations, Radio, Phones, Music etc)*** | | | | | |
| ***Noise from Outdoor (Traffic, Corridors etc)*** | | | | | |

**Thank you**

## Bio-data

### A. Personal Data

| | |
|---|---|
| **Name** | David Olaolu **OGUNTUNDE** |
| **Contact Address** | Department of Architecture, Lead City University, Ibadan Nigeria. |
| | +2348054224358; oguntunde.david@lcu.edu.ng |
| **Place of Birth** | Ibadan |
| **Nationality** | Nigerian |
| **Present Position** | Senior Lecturer |
| **Faculty** | Faculty of Environmental Design and Management, |
| **Department** | Department of Architecture |
| **Name and Address of Next of Kin:** | No 1, Apex Estate**,** Morili Apeke Street, along Pagun-Ogbada Road, off Oke-Omi Area, Iwo-Ibadan Way, Olodo Ibadan. |

### B. Educational Background

| Schools/Institutions | Qualifications | Dates |
|---|---|---|
| ▪ St. John's Primary School, Aremo Ibadan, Oyo State. | Primary School Leaving Certificate. | 1980 - 1986 |
| ▪ Lagelu Grammar School, Agugu Ibadan, Oyo State | West African Senior School CertificateExamination, (WASSCE). | 1986 - 1992 |
| ▪ Federal Polytechnic, Ede, Osun State | National Diploma in Architecture (ND), [Upper Credit] | 1995 - 1997 |
| ▪ Obafemi Awolowo University, Ile-Ife, Osun State | Bsc.(Hons) Arch [2nd Class Upper Division] | 2001 - 2004 |
| ▪ Obafemi Awolowo University, Ile-Ife, Osun State | Masters of Architecture (M. Arch) | 2006 - 2008 |

| | | |
|---|---|---|
| ▪ Lead City University, Ibadan | M.Phil/PhD | 2021-2025 |

C. **Awards and Fellowships**

| Awards | Fellowships | Date |
|---|---|---|
| Third Best Student in Architectural Design Studio (Part IV) | Department of Architecture, Obafemi Awolowo University, Ile-Ife, Osun State. | 2003/2004 Session |
| Commendation Letter as the Most Hardworking Corp Member with sound Initiatives & Teaching abilities/Skills. | Busy Int'l Secondary School, Nimo, Anambra State. | 2007 |
| The Most Friendly Lecturer | Architecture Students Association, The Polytechnic, Ibadan Chapter. | 2015/2016 Session |
| The Best Lecturer of the Year | Architecture Students Association, The Polytechnic, Ibadan Chapter. | 2016/2017 Session |
| The Most Friendly Lecturer | Architecture Students Association, The Polytechnic, Ibadan Chapter. | 2017/2018 Session |

**D. Work Experience**

**Present Employers and Posts held with Dates**

| Employers/Address | Designation | Courses Taught | Dates |
|---|---|---|---|
| Department of Architecture, Lead City University, Ibadan. | Senior Lecturer | • Building Components and Methods<br>• Building Climatology for Architects | October, 2023 till Date. |
| | Lecturer I | • Architectural Design.<br>• Working Drawing and Specification Writing. | October, 2021-August, 2023. |

**Previous Employers and Posts held with Dates**

| Employer/Address | Designation | Nature of Duty | Dates |
|---|---|---|---|
| Department of Architecture, The Polytechnic, Ibadan. | Part-Time Lecturer | • Lecturing | Jan. 2012 to Sept. 2021. |
| Environmental Rebranding Konsults, Plot 7 Block I, Oba Akinyele Agodi G.R.A opposite Aboyade House, Secretariat Ibadan. | Associate Partner | • Architectural Consultancy<br>• Project Management & Monitoring<br>• Planning Consultancy | 2013 till Date. |
| Boldform Consults Ltd; 1st Basement Floor, Oluseun House, 34, Oyo Road, Sango Ibadan. | Technical Manager | • Architectural Consultancy<br>• Project Management<br>• Planning Consultancy<br>• Project Coordination/Supervision | Nov. 2010 to April 2012. |
| Abode Environmental Ltd; 3, Baale Mosaderin Road, Jericho Ibadan. | Associate Architect | • Architectural Design & Consultancy<br>• Planning Consultancy<br>• Project Management & Supervision | Apr. 2009 to Sept. 2010. |

| | | | |
|---|---|---|---|
| Archi-Hives; Plot 7 Block I, Oba Akinyele Agodi G.R.A opposite Aboyade House, Secretariat Ibadan. | Project Architect | • Project Planning & Supervision<br>• Liaising with Contractors and Suppliers<br>• Detailing of Working Drawings and coordinating the activities of the Drafting Department. | Mar. 2007 to March 2009. |

**Courses taught in the Current First & Second Semesters, 2023/2024 Session**

| Code | Course Title | Class |
|---|---|---|
| ARC 204 | Building Components and Methods I | 200 Level |
| ARC 303 | Building Components and Methods II | 300 Level |
| ARC 301 | Architectural Design Studio II | 300 Level |
| ARC 702 | Advanced Working Drawing and Specification Writing | M.Sc I |
| ARC 731 | Advanced Design Studio IV | M.Sc II |
| ARC 214 | Building Components and Methods II | 200 Level |
| ARC 313 | Building Components and Methods III | 300 Level |
| ARC 413 | Working Drawings & Specification Writing | 400 Level |

**Number of Students Supervised at the Undergraduate and Postgraduate Levels**

| Sessions | Number of Students Supervised | |
|---|---|---|
| | **Undergraduate(400 Level)** | **Postgraduate (Msc II)** |
| *2021/2022* | 4 | 2 |
| *2022/2023* | 4 | 2 |
| *2023/2024* | 7 | 3 |

## E. Membership of Academic Professional Bodies

| Class | Professional Body | Reg. No. | Date |
|---|---|---|---|
| **Full Registration.** | Architects Registration Council of Nigeria (ARCON) | **F/3890** | August, 2017. |
| **Member** | Nigerian Institute of Architects | **M/4230** | November, 2020 |



## F. Publications

- **Thesis / Dissertation**

Oguntunde, D.O., ***The Design of a Library Complex for the Federal Polytechnic, Ede, Osun State*** being a Design Seminar presented and submitted to the Department of Architecture, Obafemi Awolowo University, Ile Ife Osun State in Partial Fulfilment of the Requirement for the Award of Master in Architecture (M.Arch), 2008,

Oguntunde, D.O., ***Building Techniques of the Byzantine and Gothic Architectural Styles:Their Impact on Contemporary Architecture*** being a Project Dissertation presented and submitted to the Department of Architecture, Obafemi Awolowo University, Ile Ife Osun State in Partial Fulfilment of the Requirement for the Award of Bachelor of Science in Architecture (Bsc Arch), 2005,

- **Books/ Monographs**

**a. Authored Books: Nil.**

**b. Edited Books: Nil**

- **Contribution to Books**

Oguntunde, D.O. & Busari, T.B., *Towards Green and Sustainable Building Design in the Built Environment: In The Constructed Environment of Nigeria* (edited by Kola Lawal & Yinka Ogundiran). Centre for Innovative Design and Development Research, Ibadan, 2020: 115-124.

Oguntunde, D.O. & Busari, T.B., *Mahoney Table Approach to Climate-Responsive Architecture and Sustainable Building Designs in Nigeria: In the Constructed Environment of Nigeria* (edited by Kola Lawal & Yinka Ogundiran). Centre for Innovative Design and Development Research, Ibadan, 2020:139-151.

- **Papers in Referred Conference Proceedings**

Oguntunde, D.O. & Adeyemi-Doro, O.B.A., *Architecture, Economic Diversification and Development: The Roles and Impacts*. Paper presented at the Conference, The Federal Polytechnic, Offa on the theme: **Impact of Technological Advancement on Economic Diversification & Development in Nigeria**, 2018.

Adeyemi-Doro, O.B.A. & Oguntunde, D.O., *The Effects of Epileptic Nature of Electricity on Nigerian Economic Diversification and Development: The Way Forward*. Paper presented at the Conference, The Federal Polytechnic, Offa on the theme: **Impact of Technological Advancement on Economic Diversification & Development in Nigeria**, 2018.

Ogunkunle, O.A; Oguntunde, D.O. & Adeyemi-Doro, O.B.A., Fire Safety in Residential Development: Design, Materials and Finishes. Paper presented at the The Faculty of Environmental Studies Conference, The Polytechnic, Ibadan on the theme**: Risk and Disaster Management in Nigeria**, 2014.

Adeoye, A.O. & Oguntunde, D.O., *Housing Poverty and Resilient Building in Nigerian Urban Centres*. Paper presented at the The Department of Urban and Regional Planning International Conference, The Polytechnic, Ibadan on the theme: **Cities in Transition: Building Resilience and Adaptation**, 2013.

- **Papers in Referred Journals**

Oguntunde, D.O., Adedire, F.M., Alagbe, O.A., Anthony, I. & Babalola, O., *Relationship between Indoor Thermal Conditions, Sleep Quality, Health and Performance in a Warm-Humid University's Students' Hostel*. **Archiculture**, 5, 1, 2023: ISSN 2636-6747. 150-160.

Oguntunde, D.O., Babalola, O., Ayoola, H.A., Anthony, I. & Alagbe, O.A., *Assessment of Students' Adaptive Behaviours to Indoor Thermal Conditions in First Technical University Hostels, Ibadan, Oyo State*. **Journal of Arts & Social Science Education (JASSE),** 2, 1, 2023: ISSN 2971-7779. 33-40.

Oguntunde, D.O., Babalola, O., Ayoola, H.A., Anthony, I. & Alagbe, O.A., *Indoor Thermal Assessment of Students' Hostel Rooms: A Case of First Technical University, Ibadan, Nigeria*. **Journal of Arts & Social Science Education (JASSE)**, 2, 1, 2023: ISSN 2971-7779. 12-25.

Oguntunde, D.O & Tokede, C.A. Nigeria's Economic Diversification and Development: A case for Improved Electricity Supply. The Yaba Journal of Environmental Research, 4, 1, 2019: ISSN 2006-6651. 35-48.

Tokede, C.A., Oguntunde, D.O. & Adeoye, A.O., *The Roles and Impacts of Architecture to Economic Diversification and Development.* **The Yaba Journal of Environmental Research**, 4, 1, 2019: ISSN 2006-6651. 49-60.

Oguntunde, D.O. & Adeyemi-Doro, O.B.A., *Slum Occurrence in Ibadan: Formation Factors and Architects' Roles to Slum Prevention and Control.* **International Journal of Environmental Design and Construction Management (IJECM),** 11, 3, 2017: ISSN 2325-1884. 119-143.

Oguntunde, D.O. & Adeyemi-Doro, O.B.A., *Ibadan Flood Disasters: Causes, Vulnerability and Socio-Economic Effects.* **African Scholar Journal of Environmental and Construction Management (AJECM)**, 9, 3, 2017: ISSN 1896-6783. 24-143.

Oguntunde, D.O. & Adeyemi-Doro, O.B.A., *The Challenge of Urban Growth and Urbanization: A Case of Ibadan, Nigeria.* **Sub-Sahara Journal of African Sustainable Development (JASUD)**, 8, 7, 2017: ISSN 2115-4255. 69-91.

Oguntunde, D.O. & Adeyemi-Doro, O.B.A., *Climate-Responsive Approaches for South-Western Nigeria Residential Building Designs: A Case of Ibadan.* **Berkeley Research and Publications International Journal of Environmental Design and Construction Management (IJECM)**, 6, 3, 2017: ISSN 1933-1948. 173-197.

Oguntunde, D.O; Adeyemi-Doro, O.B.A. & Oladunjoye, K.G.K., *Role of Architecture as a Key-Drive to Nigeria Economic Development.* **Journal of Science and Engineering Perspectives**, 12, 2017: ISSN 1115-8336. 120-133.

Adeyemi-Doro, O.B.A., Oguntunde, D.O. & Ogunkunle, O.A., *Combating the Effects of Climate Change on the Environment with Green Infrastructures.* **Journal of Science and Engineering Perspectives**, 9, 2014: ISSN 1115-8336. 80-96.

Adeyemi-Doro, O.B.A., Ogunkunle, O.A. & Oguntunde, D.O., *Low Energy Building and Mitigation of the Impending Danger of Climate Change in Ibadan, Nigeria.* **Journal of Science and Engineering Perspectives**, 9, 2014: ISSN 1115- 8336. 97-114.

- **Notable Scholarly / Professional Accomplishment**

  - Departmental Award for the Third Best Student in Architectural Design Studio (Part IV), 2003/2004 Session, Obafemi Awolowo University, Ile-Ife Osun State.
  - Commendation Letter by Busy Int'l Secondary School, Nimo, Anambra State during National Youth Service Year.

**G. Professional Conferences/ Workshops Attended**

- Nigerian Institute of Architects, Oyo State Chapter AGM, *Post COVID-19 Effect on Sustainable Architecture in Nigeria,* held at Pentorise Event Centre, Ibadan on 27th to 29th July, 2021.

- Architects Colloquium, Architects Registration Council of Nigeria (ARCON), held at Shehu Musa Yar'Adua Centre, Abuja on the theme: *Architecture and the National Development Agenda X: Architecture, Urbanization and National Security,* 24th to 27th April, 2017.
- Architects Colloquium, Architects Registration Council of Nigeria (ARCON), held at Shehu Musa Yar'Adua Centre, Abuja on the theme*: Architecture and the National Development Agenda IX: Urbanization and Sustainable Built Environment in Nigeria- Role of the Architect;* 25th to 28th April, 2016.

**H. Extra-Curricular Activities**

a) Associate Partner, Environmental Rebranding Konsults, Ibadan.

b) Member, Curriculum Committee, Department of Architecture, Lead City University, Ibadan.

c) Member of the Team during May 2024 ARCON Full Accreditation Visit to Ajayi Crowther University, Oyo Town, Oyo State, Nigeria.

**I. Others**

- Computer Literate – Microsoft word, Excel and Autocad.
- Hardworking, Team player and ability to work under considerable pressure.
- Excellent interpersonal and communication skills.
- High level of Honesty, Integrity, Self-regulation and Transparency.
- Willingness to Learn.
- High Teaching abilities with skills and talents.
- Working under little Supervision.

**J. Names and Addresses of Referees**

1. **Prof. C.O. Osasona**

Department of Architecture, Faculty of

Environmental Design and Management

Obafemi Awolowo University, Ile-Ife,

Osun State, Nigeria.

Tel: 0803 725 2777.

2. **Dr (Tpl) Kola Lawal,**

Principal Lecturer, Department of Urban and

Regional Planning, Faculty of Environmental Studies,

The Polytechnic, Ibadan.

Tel: 08066715525; 07051606787.



……………………………………  ……………………………………

Signature  Date

**The University Compliance Certification**

This is to certify that, David Olaolu OGUNTUNDE with matriculation number LCU/PG/002813 carried out this research work titled “Evaluation of Indoor Environmental Quality of Hostel Rooms and its effects on Students’ Wellbeing in Selected Universities in Oyo State, Nigeria” in the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo state, and is in full compliance with the approved University format and style.

………………………………… ………………………………

Signature Date