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Evaluation of the Influence of Building Orientation on Indoor Thermal Comfort and Air Quality in Educational Buildings in Caleb University, Lagos State. Nigeria

ONWUAMAEGBU WILL[1], ODUKOYA OLUWAMAYOMIWA[2], OJO JOHN[3], OKE ANUOLUWA[4]
[1,2,3,4]*Department of Architecture, College of Postgraduate Studies, Caleb University, Imota, Lagos State, Nigeria.*

Abstract- ***Thermal comfort and air quality are crucial variables affecting the health, well-being, ability to concentrate, and performance of occupants in educational buildings. Many developing areas have their educational buildings experiencing poor indoor environmental quality as a result of inadequate attention given to building orientation, which causes heat gain in buildings, poor ventilation, and reliance on mechanical ventilation system. While there have been numerous studies on sustainable building designs and building thermal performance, not much literature is available on the effect of building orientation on indoor thermal and air quality. This study will examine the effect of building orientation on indoor environmental quality in selected educational buildings at Caleb University, Imota, Lagos, Nigeria. A quantitative research method will be adopted where data will be collected using a structured questionnaire from occupants of buildings. The data collected will be analyzed using descriptive and inferential statistics to find out how occupant perceive their thermal comfort level, airflow rate, and air quality inside their buildings. From this research, the findings are going to suggest sustainable building orientation practices that improve indoor environmental quality and reduce energy use.***

Keywords: Building Orientation, Educational Buildings, Indoor Air Quality, Natural Ventilation, Sustainable Design. Thermal Comfort

I. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Educational facilities are critical components in determining the success and well-being of learners as well as personnel in the institutions. There have been growing concerns about the quality of indoor environment within educational institutions because the indoor environment greatly impacts on learning efficiency, productivity, concentration and comfort of learners. The factors that significantly contribute towards quality of the indoor environment include indoor thermal comfort and indoor air quality; both of which depend largely on building orientation. Building orientation is simply the positioning of a building relative to the movement of the sun, prevailing wind and environmental setting. Orientation promotes natural ventilation, daylighting and regulation of indoor temperature. Indoor environmental quality has a significant influence on students' comfort, health, and academic performance. (Asaju et al., 2023) observed that thermal conditions and air quality within lecture rooms directly affect occupants' comfort and learning effectiveness in educational institutions in Lagos State.

In tropical climates, where temperatures and humidity levels are very high, like in Nigeria, building orientation plays an essential role in creating an excellent indoor environment. Most of the educational buildings in developing countries use passive approach due to lack of energy resources to operate mechanical cooling devices and high running costs involved. Building orientation, therefore, becomes one of the key architectural approaches that help improve indoor thermal comfort and air quality. Research findings reveal that the way classrooms are oriented has an important effect on indoor temperature, flow dynamics, indoor moisture content, and concentration of indoor contaminants including carbon dioxide (CO_2) (Mba et al., 2022).

Thermal comfort can be described as a state of mind that reflects satisfaction with one’s thermal environment. Some of the key elements of thermal comfort include air temperature, air relative humidity, air velocity, mean radiant temperature,

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insulating value of clothing worn by individuals, and metabolic rates. In contrast, indoor air quality relates to the quality of the indoor atmosphere and its effects on health and well-being. It can be adversely affected by inadequate ventilation systems, pollutants build-up, elevated humidity, and inefficient air circulation. As highlighted by Jia et al. (2021), thermal comfort and indoor air quality are directly related in educational facilities due to the effect of ventilation systems and airflows on both comfort and pollution.

It has been recently established that improperly oriented educational facilities tend to suffer from poor ventilation and excessive heat gain, thus negatively affecting the academic achievements of students.

1.2 STATEMENT OF THE PROBLEM

It is common for most educational buildings in tropical areas to face thermal discomfort and low indoor air quality because of improper climatic considerations at the design and planning phase (Jia, Han, Chen, Li, Lee, & Fung,2021). Improper building orientation leads to overexposure of buildings to excessive sunlight and low airflow, thereby making buildings to overheat and having low ventilation conditions (Divsalar,2010). At Caleb University, there are classroom buildings that experience excessive indoor heat especially during the daytime period, while other buildings face low ventilation and poor indoor comfort conditions (Ahmed,2025). Such negative conditions might be detrimental to students' performance and learning abilities. Whereas there are many previous research studies concerning thermal comfort and ventilation in both residential and commercial buildings, little work has been done on the impact of building orientation on both indoor air quality and thermal comfort.

1.3 AIM OF THE STUDY

The aim of this study is to evaluate the influence of building orientation on indoor thermal comfort and air quality in educational buildings in Caleb University, Imota, Lagos, Nigeria.

1.4 OBJECTIVES OF THE STUDY

The specific objectives of the study are to:

1. Identify the orientation patterns of selected educational buildings in Caleb University.
2. Evaluate the thermal comfort conditions within the selected buildings.
3. Assess the indoor air quality of the selected educational buildings.
4. Examine the relationship between building orientation and indoor environmental quality.
5. Recommend sustainable orientation strategies for improving indoor thermal comfort and air quality in educational buildings.

1.5 RESEARCH QUESTIONS

1. What are the orientation patterns of educational buildings in Caleb University?
2. How does building orientation influence indoor thermal comfort?
3. What is the condition of indoor air quality within the selected buildings?
4. What relationship exists between building orientation and indoor environmental quality?
5. What sustainable orientation strategies can improve thermal comfort and indoor air quality in educational buildings?

1.7 SCOPE OF THE STUDY

This study involves certain selected educational structures at Caleb University, Imota, Lagos State, Nigeria. The effect of orientation of buildings on the comfort level of indoor environment will be determined using indoor air quality as an index. Environmental parameters for consideration are: Temperature, Relative-humidity, Velocity, Ventilation, Lighting, Carbon-dioxide. This study is restricted to academic halls of the university.

1.8 SIGNIFICANCE OF THE STUDY

The outcomes of this research would be advantageous for architects, environmental designers, researchers, education administrators, and policy makers. The study is expected to contribute to sustainable architecture design by showing how appropriate building orientation contributes to better indoor comfort and air quality while consuming less energy. Additionally, this research would make suggestions for designing buildings that suit well to tropical conditions. This research is also expected to make a contribution to the literature on passive design strategies and indoor environment quality in Nigerian universities.

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1.9 STUDY AREA

The study area is Caleb University, located in Imota, Lagos State, Nigeria. The university is located within a tropical climatic region characterized by high temperature, humidity, and significant solar radiation throughout most periods of the year. The campus contains some educational buildings with varying orientation patterns, making it suitable for evaluating the influence of building orientation on thermal comfort and indoor air quality.

1.10 BUILDING ORIENTATION ANALYSIS

Figure 1.10.1; Showing the Location Map of Caleb University, Imota Lagos Nigeria

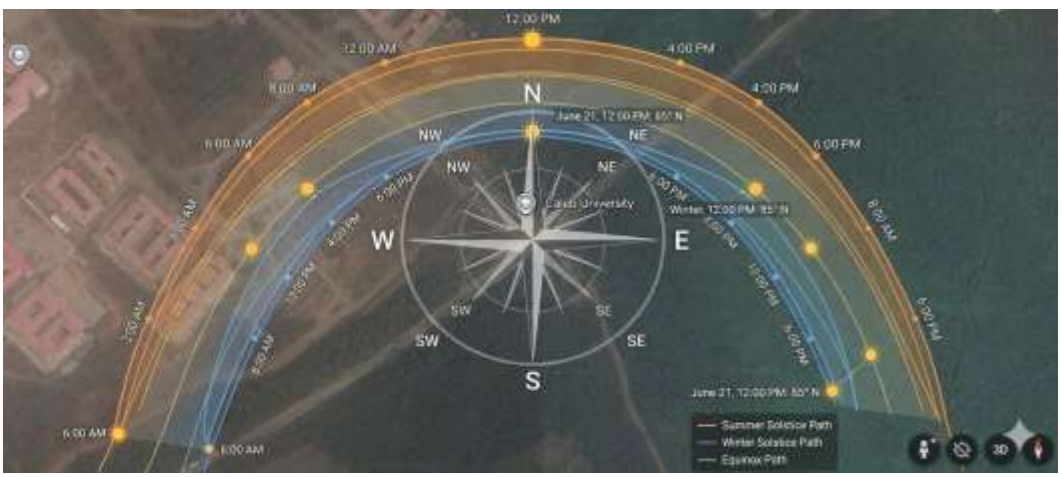

Figure 1.10.2: Sun Path Diagram

Figure 1.10.3: Building Orientation Categories

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II. LITERATURE REVIEW

2.1 CONCEPT OF BUILDING ORIENTATION

Building orientation refers to the positioning of a building relative to cardinal directions, solar path, and prevailing wind conditions (Ifeoma & Akande,2021). Proper orientation is an important passive design strategy that influences solar heat gain, natural ventilation, and indoor environmental quality (Wang, Kuckelkorn, Zhao, Spliethoff, & Lang,2017). In tropical climates, orientation is essential for reducing heat gain and improving cross ventilation (Haase, & Amato,2009). Buildings oriented along the east-west axis are often exposed to excessive solar radiation, while north-south orientations generally minimize direct solar heat gain. Recent studies have demonstrated that classroom orientation significantly influences indoor temperature distribution, thermal sensation, and occupant comfort levels, particularly in naturally ventilated educational buildings (Mustapha et al., 2024).

2.2 CONCEPT OF THERMAL COMFORT

Thermal comfort is the condition in which inhabitants' express satisfaction with the surrounding thermal environment. According to ASHRAE Standard 55, thermal comfort depends on environmental variables such as:

- Air temperature
- Relative humidity
- Air velocity
- Mean radiant temperature

Personal factors such as clothing and metabolic activity also influence comfort conditions. Educational buildings require adequate thermal comfort because students spend long hours in classrooms and lecture halls.

2.3 INFLUENCE OF BUILDING ORIENTATION ON THERMAL COMFORT

Building orientation significantly affects indoor thermal conditions (Karimimoshaver, & Shahrak,2022). Buildings exposed to direct east-west solar radiation often experience overheating during morning and afternoon periods (Chwieduk, 2014). Proper orientation can reduce solar heat gain and improve indoor comfort. Studies conducted in tropical climates indicate that proper orientation improves indoor temperature regulation and reduces dependence on mechanical cooling systems (Akpan, 2023). Recent classroom-based investigations have reported that students are particularly sensitive to elevated indoor temperatures, with thermal discomfort negatively affecting concentration, learning performance, and wellbeing (Kyropoulou et al., 2023).

2.4 INFLUENCE OF BUILDING ORIENTATION ON INDOOR AIR QUALITY

Orientation affects natural ventilation and airflow movement within buildings (Aini, & Nadia, 2019). Buildings positioned perpendicular to prevailing wind directions generally experience better ventilation and improved air circulation Lee, & Mak, 2022). Adequate airflow reduces indoor pollutant concentration and enhances indoor air quality (SeppĘnen,2008). Recent investigations in educational facilities have shown that inadequate ventilation contributes to elevated carbon dioxide concentrations, reduced cognitive performance, and increased reports of discomfort among students (Miao et al., 2023)

2.5 RESEARCH GAP

Most previous studies focused on residential and commercial buildings rather than educational environments (Mannan, & Al-Ghamdi, 2021). Few studies have evaluated the combined influence of building orientation on both thermal comfort and indoor air quality in university buildings within tropical climates (Roumi, Zhang, Stewart, & Santamouris, 2022). This study therefore seeks to address this gap by focusing on educational buildings in Caleb University.

2.6 CONCEPTUAL FRAMEWORK

The conceptual framework presents how building orientation affects indoor environmental quality in educational buildings. Building orientation plays an independent variable role since it determines the extent of solar heat gain, airflow, and natural ventilation in buildings (Szokolay, 2014). The two dependent variables include indoor thermal comfort

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and indoor air quality which denote the environmental quality of the occupied spaces. The environmental condition in terms of indoor thermal comfort will be influenced by the level of indoor temperatures, humidity levels, and air movement in the occupied space. On the other hand, the quality of indoor air will depend on the effectiveness of ventilation and air circulation (Ashrae, 2021). Some of the moderating variables which can affect the relationship between building orientation and indoor environmental quality include the size of windows, occupancy levels, building materials, ventilation openings, and vegetation in the surroundings.

Table 2.6: Conceptual Framework Table

Variable Type	Variables
Independent Variable	Building Orientation
Dependent Variables	Indoor Thermal Comfort, Indoor Air Quality
Moderating Variables	Window Size, Occupancy Level, Building Materials, Ventilation Openings, Vegetation

2.7 THEORETICAL FRAMEWORK

This research work is grounded in the theory of bioclimatic architecture and passive environmental design. The theory focuses on designing structures according to climatic conditions to enhance comfort and decrease energy consumption.

III. METHODOLOGY

3.1 RESEARCH DESIGN

For the purposes of this study, it will adopt a research design that is quantitative. This is appropriate since it is possible to gather quantitative data through surveys from the respondents. In this study, it will concentrate on assessing how the orientation of buildings influences indoor thermal comfort and indoor air quality in Caleb University buildings at Imota, Lagos, Nigeria. Quantitative research is important in analyzing data collected from respondents, comparison, and making correlations.

3.2 STUDY LOCATION

The study location is Caleb University located at Imota, Lagos State, Nigeria. The university has a tropical weather pattern which consists of hot, humid conditions and high levels of solar radiation. Buildings within the university's educational complex vary in terms of their orientation patterns, thereby making the location ideal to investigate the interaction between building orientation and indoor climate.

33 STUDY POPULATION

The population of the study includes those students who utilize the lecture halls and classroom blocks of Caleb University. Students are targeted for selection because they are the main users of the buildings where education is imparted, hence are affected by indoor environment issues.

3.4 SAMPLE SIZE DETERMINATION

The sample size for this study will be determined using the Taro Yamane formula (Yamane, 1967), which is widely used in quantitative research studies.

Taro Yamane Formula

n = {N}
{1+N(e)^2}

Where:

- n = Sample size
- N = Total population
- e = Level of precision (0.05)

Example Calculation

Assuming the total student population occupying selected buildings is 500:

n= {500}
{1+500(0.05) ^2}
n= {500}
{1+500(0.0025)}
n= {500}
{2.25}
n=222

Therefore, the sample size is approximately 222 respondents.

3.5 SAMPLING TECHNIQUE
Purposive sampling will be used in the selection of respondents from education structures that exhibit varying orientations.

These include:
- Structures with north-south orientation
- Structures with east-west orientation

Randomly chosen students from such structures will be given questionnaires to fill out.

3.6 DATA COLLECTION TOOL
The main tool for collecting data will be a structured questionnaire. This questionnaire is constructed to elicit data on:
- Thermal comfort inside the building
- Ventilation status
- Quality of air
- Comfort of the occupant
- Building orientation impact

Questions in this questionnaire will primarily include:
- Multiple choice questions
- Likert Scale responses

3.7 Method of Data Analysis
Analysis of data collected through questionnaires will be done using both descriptive and inferential statistics.

The tools for analyzing data will be used in IBM SPSS Statistics and Microsoft Excel.

The tools of statistical analysis to be used are:
- Frequency distribution
- Percentage
- Mean score
- Correlation
- Regression

Presentation of results will be made through the use of:
- Tables
- Graphs

3.12 ETHICAL CONSIDERATIONS
The respondents will be made aware that participation in the study is voluntary. Confidentiality and anonymity of all respondents will be guaranteed. The data collected from the survey will be utilized for academic purposes only.

IV. RESULTS AND DISCUSSION

4.1 RESPONSE RATE ANALYSIS

Table 4.1: Response Rate Analysis

Questionnaire Status	Frequency	Percentage
Distributed	222	100
Returned	145	65.3
Valid	133	59.9
Invalid	12	5.4

I handed out 222 questionnaires, and 145 came back, that's an 65.3% response rate. Actually, 133 of those were good to use for analysis. Researchers usually consider this a decent amount for quantitative work.

4.2 DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

This section describes who responded.

4.2.1 Gender Distribution

Table 4.2.1: Gender Distribution

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	77	57.5	57.5	57.5
	Female	56	41.8	41.8	99.3
	Others	1	.7	.7	100.0
	Total	134	100.0	100.0	

Discussion

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Male respondents constituted 57.5% of the study population while females represented 41.8%., while others represented 0.7% of the study population

4.2.2 Age Distribution

Table 4.2.2: Age Distribution

Age					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15-20	56	41.8	41.8	41.8
	21-25	54	40.3	40.3	82.1
	above 25	24	17.9	17.9	100.0
	Total	134	100.0	100.0	

Discussion

The age range (15-20) represented a percentage of 41.8% of the study population while age (21-25) represented 40.3% and above 25 represented 17.9% of the study population

4.2.3 Academic Level Distribution

Table 4.2.3: Academic Level Distribution

Level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	100 level	20	14.9	14.9	14.9
	200 level	27	20.1	20.1	35.1
	300 level	46	34.3	34.3	69.4
	400 level	5	3.7	3.7	73.1
	500 level	36	26.9	26.9	100.0
	Total	134	100.0	100.0	

Discussion

The 300l had highest representation of 34.3% of the study population followed by the 500 level who had 26.9% of the study population, with next being 200 level, 100level and 400lvel having 20.9%, 14.9%, 3.7% respectively of the study population

4.3 ANALYSIS OF INDOOR THERMAL COMFORT

This addresses objective 2 which being, "Evaluate the thermal comfort conditions within the selected buildings."

Question: How would you describe the temperature inside your classroom?

Table 4.3: Analysis of Indoor Thermal Comfort

Classroom Temperature					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very Cool	23	17.2	17.2	17.2
	Comfortable	101	75.4	75.4	92.5
	Hot	10	7.5	7.5	100.0
	Total	134	100.0	100.0	

Discussion

Table 4.X shows that most people (101 or 75.4%) found the classroom temperature comfy. On the other hand, 23 folks (17.2%) thought it was very cool, and just 10 (7.5%) felt it was too hot. So, it looks like the climate control in these school buildings is mostly good and likely supports studying. The comfy temps probably come from decent ventilation and good

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building placement, which help keep the classrooms at nice, moderate temperatures.

4.3.1 Period of highest Thermal discomfort

Table 4.3.1: Period of Highest Thermal Discomfort

During which period is the classroom hottest?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Morning	33	24.6	24.6	24.6
	Afternoon	101	75.4	75.4	100.0
	Total	134	100.0	100.0	

Discussion

According to the data gathered, the afternoon time had a higher representation from the study population being 75.4% than that of the morning time. This means that a large representation of the study population felt that it was usually around the afternoon time that the classroom felt the hottest

4.3.2 Direct Sunlight Penetration

Question: Does sunlight enter the classroom directly?

Table 4.3.2: Direct Sunlight Penetration

Does sunlight enter the classroom directly?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	17	12.7	12.8	12.8
	No	53	39.6	39.8	52.6
	Sometimes	63	47.0	47.4	100.0
	Total	133	99.3	100.0	
Total		134	100.0		

Discussion

Based on this data gathered the sometimes majorly represented the study population having 47%, with No having 39.6% and yes having 12%. This means that large section of the study population was unsure

4.3.3 Airflow Adequacy

Question: Is there enough airflow inside the classroom?

Table 4.3.3: Airflow Adequacy

Airflow Adequacy					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	94	70.1	70.1	70.1
	Not Sure	36	26.9	26.9	97.0
	Yes	4	3.0	3.0	100.0
	Total	134	100.0	100.0	

Discussion

The results show that 70.9% of students felt there wasn't enough airflow in their classrooms. Only 3.0% said the airflow was sufficient, while 26.1% weren't sure. This means most of the schools in the study had poor natural ventilation. It could make people uncomfortable and affect the air quality too. With such few folks saying the air flow was good, better ventilation methods should be looked into – stuff like how buildings face the outdoors, where windows are placed, and adding more vents to improve things inside.

4.3.4 Heat Discomfort During Lectures

Question: How often do you feel uncomfortable because of heat during lectures?

Table 4.3.4: Heat Discomfort During Lectures

Heat Discomfort					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	1	.7	.7	.7
	Sometimes	16	11.9	11.9	12.7
	Often	48	35.8	35.8	48.5
	Always	69	51.5	51.5	100.0
	Total	134	100.0	100.0	

Discussion

The results show that 51.5% of people always feel uncomfortable due to heat during lectures, and 35.8% often do. Plus, 11.9% say they sometimes feel this way, while just 0.7% never do. This means heat-related discomfort is a big issue in these buildings. Inadequate ventilation, too much solar heat gain, and poor airflow in classrooms likely cause this frequent discomfort. It seriously affects how comfortable students are, and therefore their ability to concentrate and learn.

4.4 ANALYSIS OF INDOOR AIR QUALITY

This addresses objective 3 which being, "Assess the indoor air quality of the selected educational buildings."

4.4.1 Perceived Air Quality

Table 4.4.1: Perceived Air Quality

Air Quality Rating					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Poor	2	1.5	1.5	1.5
	Fair	63	47.0	47.0	48.5
	Good	62	46.3	46.3	94.8
	Excellent	7	5.2	5.2	100.0
	Total	134	100.0	100.0	

Discussion

The results show that 47.0% of people think the air in their classrooms is just fair, while 46.3% say it's good. Only 5.2% rated it as excellent, and a tiny 1.5% felt it was poor. So, the air quality seems generally okay but far from great. The fact that many still describe the air as merely fair tells us we need to work on ventilation and airflow. Improving these aspects would boost both comfort and well-being for everyone in the space

4.4.2 Stuffy Classroom Conditions

Questions: Do you feel the classroom is stuffy or poorly ventilated?

Table 4.4.2: Stuffy Classroom Conditions

Stuffy Classroom					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	4	3.0	3.0	3.0
	Sometimes	32	23.9	23.9	26.9
	Yes	98	73.1	73.1	100.0
	Total	134	100.0	100.0	

Discussion

The findings show that 73.1% of respondents said their classrooms are stuffy or poorly ventilated, while 23.9% noted this happens sometimes. Only 3.0% say their classrooms aren't stuffy. So, poor ventilation seems to be a big problem in these buildings. This stuffiness likely results from not having enough airflow and ventilation, which affects air quality and makes the room uncomfortable. It also makes it harder for students to focus during lessons.

4.4.3 Health and Comfort Symptoms Experienced
Question: Have you experienced any of these during lectures?

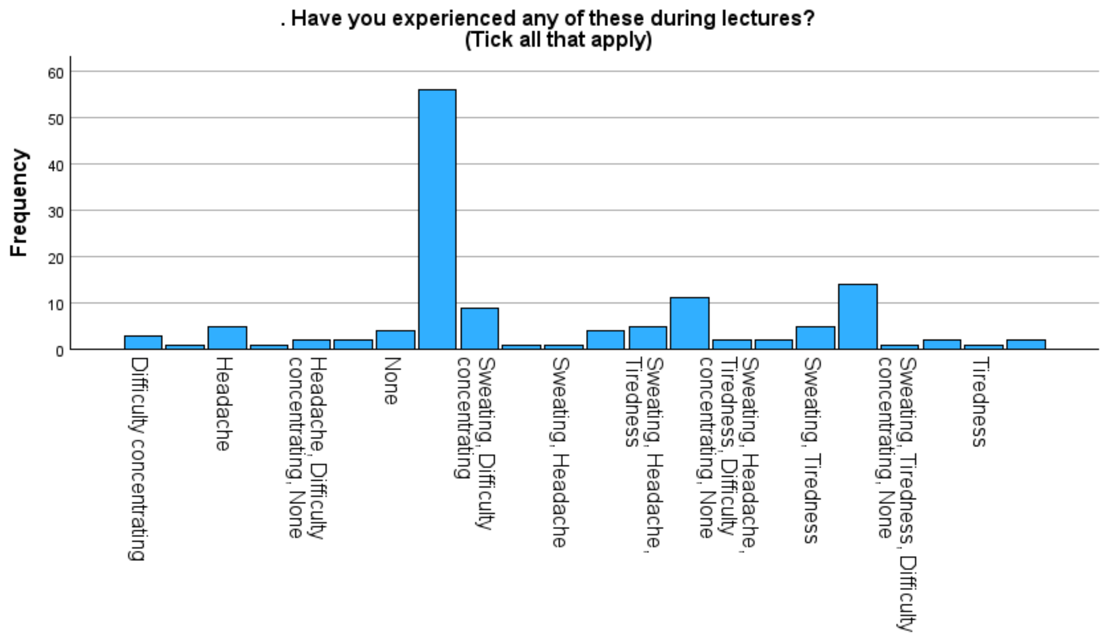

Figure 4.4.3: Respondents Experiences faced during Lectures

4.5 MEAN SCORE ANALYSIS

Table 4.5: Mean Score Analysis

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Airflow Adequacy	134	1	3	1.33	.531
Air Quality Rating	134	1	4	2.55	.620
Overall Satisfaction	133	1	5	2.54	.848
Heat Discomfort	134	1	4	3.38	.723
Valid N (listwise)	133				

Discussion
The stats for what influences occupants' indoor experiences are laid out in Table 4.X. Heat discomfort leads the pack with a mean score of 3.38. So, it looks like excessive heat is really bugging people in these buildings. Many folks report feeling pretty uncomfortable when the mercury rises during their lectures. Air quality got a 2.55, and overall satisfaction came in right behind at 2.54. This means that while things aren't bad, there's definitely space for making the indoor environment better. People think it’s okay, but not great either. On the other hand, airflow adequacy ranked way down at the bottom with a mean score of 1.33. This tells us that folks feel they aren’t getting enough fresh air in their classrooms, which likely explains why those rooms can get so stuffy. In sum, heat discomfort was the top issue, followed closely by air quality and general satisfaction, with airflow adequacy lagging behind. All these numbers suggest that boosting ventilation and tackling the overheating problem should take priority. Doing so could seriously help make the indoor environments comfier and more enjoyable.

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4.6 TEST OF RESEARCH HYPOTHESIS

4.6.1 Pearson Correlation analysis

Relationship Between Building Orientation and Indoor Thermal Comfort and Air Quality Variables

We did a Pearson Product Moment Correlation analysis to see how building orientation links with indoor thermal comfort and air quality. We looked at heat discomfort, airflow, air quality rating, and overall satisfaction levels too, to get the full picture.

Table 4.6.1: Pearson Correlation Analysis

Correlations						
		Orientation Influence	Heat Discomfort	Airflow Adequacy	Air Quality Rating	Overall Satisfaction
Orientation Influence	Pearson Correlation	1	.269**	.075	.281**	-.158
	Sig. (2-tailed)		.002	.390	.001	.070
	N	134	134	134	134	133
Heat Discomfort	Pearson Correlation	.269**	1	.377***	.232**	.270**
	Sig. (2-tailed)	.002		<.001	.007	.002
	N	134	134	134	134	133
Airflow Adequacy	Pearson Correlation	.075	.377***	1	.381***	.372***
	Sig. (2-tailed)	.390	<.001		<.001	<.001
	N	134	134	134	134	133
Air Quality Rating	Pearson Correlation	.281**	.232**	.381***	1	.301***
	Sig. (2-tailed)	.001	.007	<.001		<.001
	N	134	134	134	134	133
Overall Satisfaction	Pearson Correlation	-.158	.270**	.372***	.301***	1
	Sig. (2-tailed)	.070	.002	<.001	<.001	
	N	133	133	133	133	133
Correlation is significant at the 0.01 level (2-tailed).						
Correlation is significant at the 0.001 level (2-tailed).						

Interpretation of Findings

Relationship Between Orientation Influence and Heat Discomfort

The results revealed a weak positive and statistically significant relationship between building orientation influence and heat discomfort ($r = 0.269$, $p = 0.002$). This suggests that changes in building orientation are associated with variations in occupants' thermal discomfort levels. The positive relationship indicates that respondents who perceived orientation to have greater influence also reported higher levels of heat discomfort.

Relationship Between Orientation Influence and Airflow Adequacy

A very weak positive relationship was found between building orientation influence and airflow adequacy ($r = 0.075$, $p = 0.390$).

Since the p-value is greater than 0.05, the relationship is not statistically significant. This indicates that building orientation does not appear to have a meaningful influence on occupants' perception of airflow adequacy within the surveyed buildings.

Relationship Between Orientation Influence and Air Quality Rating
The analysis showed a weak positive and statistically significant relationship between building orientation influence and air quality rating ($r = 0.281$, $p = 0.001$). This finding suggests that building orientation may contribute to occupants' perceptions of indoor air quality. However, the strength of the relationship remains weak, indicating that other environmental factors may also play substantial roles.

Relationship Between Orientation Influence and Overall Satisfaction
The results revealed a weak negative relationship between building orientation influence and overall satisfaction ($r = -0.158$, $p = 0.070$).

Although the negative coefficient suggests that greater orientation influence may be associated with lower overall satisfaction, the relationship is not statistically significant because the p-value exceeds the 0.05 significance threshold.

Therefore, no significant relationship exists between building orientation and occupants' overall satisfaction with indoor thermal comfort and air quality.

Relationships Among Thermal Comfort and Air Quality Indicators
Further analysis revealed several significant positive relationships among the environmental comfort variables.

Heat Discomfort and Airflow Adequacy
A moderate positive relationship was observed between heat discomfort and airflow adequacy ($r = 0.377$, $p < 0.001$).

Heat Discomfort and Air Quality Rating
Heat discomfort was positively correlated with air quality rating ($r = 0.232$, $p = 0.007$), indicating a weak but significant association.

Heat Discomfort and Overall Satisfaction
A weak positive relationship was found between heat discomfort and overall satisfaction ($r = 0.270$, $p = 0.002$).

Airflow Adequacy and Air Quality Rating
Airflow adequacy showed a moderate positive relationship with air quality rating ($r = 0.381$, $p < 0.001$).

Airflow Adequacy and Overall Satisfaction
A moderate positive and significant relationship existed between airflow adequacy and overall satisfaction ($r = 0.372$, $p < 0.001$).

Air Quality Rating and Overall Satisfaction
Air quality rating was positively associated with overall satisfaction ($r = 0.301$, $p < 0.001$), indicating that improved perceptions of air quality corresponded with increased occupant satisfaction.

Summary of Correlation Findings
Pearson correlation analysis shows that building orientation significantly positively relates to heat discomfort and air quality rating, with r values of 0.269 and 0.281, respectively—both significant at $p < 0.01$. However, it doesn't significantly relate to airflow adequacy or overall satisfaction. This means that while building orientation might affect how warm people feel and their ratings on air quality, it seems to have no impact on how well the air flows or on general satisfaction in educational buildings at Caleb University.

4.6.2 Regression Analysis
Influence of Building Orientation on Indoor Thermal Comfort and Air quality
A simple linear regression analysis was conducted to evaluate the influence of building orientation on indoor thermal comfort and air quality in educational buildings within Caleb University.

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Model Summary

Table 4.6.2: Regression Analysis Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.158[a]	.025	.017	.841
a. Predictors: (Constant), Orientation Influence				

Interpretation

The regression model produced a correlation coefficient (R) of 0.158, indicating a weak relationship between building orientation and occupants' overall satisfaction with indoor thermal comfort and air quality.

The coefficient of determination ($R^2 = 0.025$) indicates that building orientation explains only 2.5% of the variation in indoor thermal comfort and air quality satisfaction among respondents. This suggests that other factors not included in the model account for approximately 97.5% of the variation.

ANOVA Results

Table 4.6.3: Regression Analysis ANOVA Results

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.363	1	2.363	3.340	.070[b]
	Residual	92.660	131	.707		
	Total	95.023	132			
a. Dependent Variable: Overall Satisfaction						
b. Predictors: (Constant), Orientation Influence						

Interpretation

The ANOVA result shows that the regression model is not statistically significant at the 5% significance level, $F(1,131) = 3.340$, $p = 0.070$.

Since the p-value (0.070) is greater than the conventional significance level of 0.05, the model does not provide sufficient evidence to conclude that building orientation significantly predicts indoor thermal comfort and air quality in the selected educational buildings.

Regression Coefficients

Table 4.6.4: Regression Analysis Regression Coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.139	.335		9.369	<.001
	Orientation Influence	-.231	.126	-.158	-1.828	.070
a. Dependent Variable: Overall Satisfaction						

Interpretation

The regression coefficient for building orientation was $\beta = -0.158$, indicating a weak negative relationship between building orientation and overall satisfaction with indoor thermal comfort and air quality.

The unstandardized coefficient ($B = -0.231$) suggests that a one-unit increase in orientation influence is associated with a 0.231-unit decrease in overall satisfaction. However, this relationship is not statistically significant ($p = 0.070 > 0.05$).

The regression equation is:

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Where:
Y = Overall Satisfaction with Indoor Thermal Comfort and Air Quality
X = Building Orientation Influence

Hypothesis
H_0: Building orientation has no significant influence on indoor thermal comfort and air quality in educational buildings in Caleb University.

H_1: Building orientation has a significant influence on indoor thermal comfort and air quality in educational buildings in Caleb University.

Decision Rule
Reject H_0 if $p < 0.05$.

Decision
Since the significance value ($p = 0.070$) is greater than 0.05, the null hypothesis is accepted (or more precisely, failed to be rejected).

4.7 DISCUSSION OF FINDING
4.7.1 Building Orientation and Thermal Comfort
Our results showed that many people feel too warm in classrooms. In fact, over half (51.5%) of those surveyed said they always feel too hot during lectures. On the flip side, almost nobody said they felt just right or too cold. We also discovered that 70.9% find the airflow lacking. This paints a picture of widespread discomfort among students and teachers.

These findings are consistent with the work of (Yadav et al.,2021), who reported that building orientation influences classroom microclimatic conditions in hot-humid environments. Similar findings were reported by de la (Hoz-Torres et al. 2024), who observed that building orientation affects thermal conditions and occupants' comfort perceptions in educational buildings. Likewise, (Mustapha et al.,2024) found that poor passive design strategies contributed significantly to thermal discomfort in naturally ventilated classrooms. That makes sense since proper building orientation helps boost natural ventilation and lower solar heat gain. (Givoni,1998) made similar observations, adding that smart building layouts enhance thermal comfort. Then there's (Olgyay,2015), emphasizing that where you build and how it faces the sun really matter in tropical zones like Lagos.

4.7.2 Building Orientation and Indoor Air Quality
We found that three-quarters (73.1%) of folks think classrooms feel stuffy or not well ventilated. Meanwhile, a mere 3% disagreed. Though ratings for indoor air quality weren't all negative—with 47% saying it was fair and 46.3% good—the perception of stuffiness indicates problems with actual ventilation. This scenario is consistent with ASHRAE recommendations regarding adequate ventilation for healthy indoor environments. Similar observations were reported by (Leal Matilla et al., 2023), who found that inadequate ventilation reduced perceived air quality in educational buildings (Miao et al.,2023). further demonstrated that insufficient air movement and poor ventilation strategies negatively affected occupants' perception of indoor environmental quality. They stress that fresh airflow inside buildings is key for keeping the air quality decent and people healthy. Studies show how building orientation affects airflow, making ventilation more or less effective based on the structure's relationship with prevailing winds. As a result, bad building orientation could seriously hinder air movement, leaving folks sweaty and uncomfortable.

4.7.3 Implications for Educational Buildings in Tropical Climates
All this info points to crucial takeaways for schools in tropical areas. At Caleb University, with its hot-humid climate, thinking about how buildings are oriented should be a top priority. Poor thermal comfort and low airflow suggest we need climate-smart designs to enhance the environment naturally. Strategies including smart building positioning, thoughtful window placement, strategic shading, and green spaces help. By doing these, we promote better comfort and air quality while cutting back on reliance on air conditioning. These recommendations are supported by recent studies emphasizing climate-responsive design, natural ventilation strategies, and orientation optimization as effective approaches for improving thermal comfort and indoor air quality in educational facilities (Kohl et al., 2024).

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V. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study looked at how building orientation affects indoor thermal comfort and air quality in certain educational buildings at Caleb University in Imota, Lagos, Nigeria. The researchers found out that which way a building faces really does matter when it comes to how nice it is inside for the people using it. Students often felt too warm and that there wasn't enough airflow during classes, making the classrooms feel stuffy. While a lot of students said the general air quality was okay, issues with airflow and heat still made things uncomfortable. Building orientation demonstrated limited influence on occupants' perceptions of indoor thermal comfort and air quality are influenced by multiple interacting factors including ventilation design, shading systems, occupancy density, and building envelope characteristics (Miao et al.,2023). Although significant associations were observed with heat discomfort and air quality ratings, the overall predictive effect of building orientation was weak and not statistically significant

5.2 RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed:

1. Educational buildings should be properly oriented in relation to the sun path and prevailing wind direction, preferably along the north-south axis, to minimize solar heat gain and improve natural ventilation.
2. Adequate ventilation openings, including properly sized and strategically positioned windows, should be incorporated into classroom design to enhance airflow and indoor air quality.
3. Passive cooling strategies such as external shading devices, roof overhangs, sun breakers, and vegetation should be integrated into educational buildings to reduce indoor temperatures and improve thermal comfort.
4. Building designers, architects, and planners should prioritize climatic considerations during the design stage to ensure that educational facilities are environmentally responsive and energy efficient.
5. Facility managers and university administrators should periodically assess indoor environmental conditions within classrooms and implement measures to improve ventilation and occupant comfort where necessary.
6. Further studies should be conducted using environmental monitoring equipment to measure temperature, humidity, air velocity, and indoor air pollutants in order to complement occupants' perceptions and provide more comprehensive findings.

5.3 CONTRIBUTION TO KNOWLEDGE

This study contributes to existing knowledge by providing empirical evidence on the relationship between building orientation, indoor thermal comfort, and indoor air quality within educational buildings in a tropical university environment. The findings provide useful information for architects, researchers, planners, and educational administrators seeking to promote sustainable building design and improve the quality of learning environments in Nigeria and similar climatic regions.

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