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INFLUENCE OF CONDITION OF WALL ELEMENTS ON OCCUPANT'S THERMAL SENSATION IN LECTURE THEATRES IN OWERRI CAPITAL TERRITORY, IMO SATE NIGERIA

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Abstract

This study focused on assessing the impact of the condition of the wall elements on occupants' thermal sensation in lecture theatres in tertiary institutions in Owerri Capital Territory, Imo State, Nigeria. These institutions are Federal university of Technology Owerri (FUTO), Alvan Ikoku Federal university of Education (AIFUE), Imo State University, Owerri (IMSU) and Federal polytechnic Nekede (FEDPONEK). The study adopted the adaptive comfort theory and the operant conditioning theory, which emphasizes that a relationship exists between the occupants, and the built environment that builds on continuous changes to the environment and the occupants' behaviours. The study employed a quantitative survey method, and data were collected using observational and questionnaire methods. The results from the lecture theatres studied showed that, 54.6% of the walls, 53.4% of the windows, 46.3% of the doors, and 54.3% of the wall finishes which were compressed as a composite variable (representing conditions of the wall elements) of the lecture were in poor conditions. A Biserial Correlation coefficient value of -0.161, and a significance probability value of 0.003 statistically showed that the condition of the wall elements truly had a correlation with thermal sensation of the users. The study recommends the use of appropriate building materials and regular appraisal of the facilities by facility condition assessors to ascertain the condition of the facilities in the institutions.

Keywords: State of Building Fabric, Lecture Theatre, Environment, Thermal Sensation, and Thermal Comfort

INTRODUCTION

The expectation for lecture theatres is to provide suitable thermal conditions that ensure occupant comfort and productivity. This is typically accomplished through the utilization of robust and efficient building materials with adequate thermal characteristics. The wall elements which remain an integral part of the building fabric, alongside the roof and floor elements, separates the building's exterior from its interior, substantially affecting air flow and heat transmission within the structure (Straub, 2009). The roof and wall elements, which are the most exposed parts receiving direct solar radiation that penetrates the building, primarily regulates heat gain or loss. The use of inappropriate choices of wall elements and material finishes has resulted in poor thermal performance of the building structures, which needs to be improved upon. Abdulkareem, (2016) and Qaid et al (2016) noted that improving thermal comfort requires experts using building fabrics with effective heat absorption and reflective properties.

ASHRAE Standard 55 (2017) described thermal comfort as that condition of the mind that expresses satisfaction with the thermal environment. The document further stated that this condition varies physiologically and psychologically from one person to another and from space to space, particularly naturally ventilated spaces. De Abreu-Harbich et al (2018) noted that thermal comfort is associated with well-being and health of occupants, which needs to be addressed in the classroom considering the amount of time the occupants spend in the building. Thermal comfort in the lecture theatre is very important to academic performance (Sarbu & Pacurar, 2015, Toftum et al, 2015). However, lack of adequate thermal comfort causes dissatisfaction, decreased mood, increased stress behaviours, sluggishness of the human system, and general poor thermal perception that affects well-being and academic performance (Akande, et al, 2021; Ifebi, Olotuah & Ezeji, 2020; Munonye & Ji, 2018; Ricardo, et al, 2015; Singh, et al, 2018). De Abreu-Harbich et al, (2018) further stated that thermal comfort is related to the climatic conditions, architectural characteristics, and particularly the materials used in the construction of the buildings.

The thermal comfort of the occupants is associated with the state of the buildings' fabrics as established in the literature (Sadick, 2018; Munonye & Ji, 2019). The state of the wall elements can be hampered due to poor handling while in use, poor construction characteristics and lack of maintenance. These factors result in poor thermal performance of the wall elements and the entire building fabric. Abbott *et al*, (2007) described a building's state as the physical condition of its structural components, which can be used to evaluate its functional performance. Various studies, including Aniefiok, (2021), Munonye and Ji, (2019), Mustafa, (2017), Sadick, (2018), Frontczak and Wargocki (2011), Lawal and Ojo (2011), and Okafor and Onyegiri, (2019), further affirmed that a building's state significantly influences its thermal performance and, consequently, productivity and the thermal comfort of the occupants. However, in Owerri Capital Territory, Imo Sate Nigeria, which is the focus area of study, poor physical states of the buildings can be observed. The poor physical condition of these lecture theatres hampers the attainment of optimal thermal performance of the structures and that influences the thermal sensation of the occupants. This paper therefore will focus on how the state of wall elements affects occupants' thermal sensation in lecture theatres in Owerri Capital Territory, Imo Sate Nigeria.

This study is part of a wider research on the physical conditions and thermal comfort in lecture theatres in tertiary educational institutions in Owerri, Imo State Nigeria. It sought to resolve the question whether the state of the building fabrics has a significant relationship with thermal comfort in the lecture theatres of tertiary institutions in Owerri Capital Territory. The guiding hypothesis (Ho) was that there is no significant relationship between the condition of the wall elements and thermal comfort sensation vote in the lecture theatres in tertiary institutions in the study area.

LITERATURE REVIEW

Thermal comfort refers to a mental state of satisfaction with the thermal environment, which can be evaluated subjectively (ASHRAE, 2017). It is influenced by environmental factors, occupant characteristics, and building features (Akadiri, Chinyio & Olomolaiye, 2012; Arif, Katafygiotou, Mazroei, Kaushik & Elsarrag, 2016; Ifebi, Olotuah & Ezeji, 2020). Alfa *et al* (2019) emphasized the importance of buildings as interfaces between the physical environment and occupants. Olanrewaju, (2012) highlighted that buildings are crucial assets for universities. A nation's growth is linked to the productivity and performance of its population, who thrive in comfortable environments. Conversely, when the built environment negatively impacts occupant's health, the nation suffers (Alfa *et al*, 2019). Subair (2012) concluded that student output quality is dependent on infrastructure, which shapes the learning environment.

Lecture theatres, as institutional structures, significantly influence the comfort and well-being of the occupants. These spaces, where students dedicate nearly 90% of their study time, face critical interior thermal comfort issues that impact student performance (Neelesh & Kavita, 2022, Chen *et al*, 2020). According to the National Universities Commission (NUC, 2004), many Nigerian lecture theatres are either not properly procured or in a state of disrepair. Subair (2012) further noted the deplorable condition of these buildings and highlighted the absence of facilities for effective practical learning, especially in technology-focused universities. Okolie (2006) and Obi-George (2024) thus noted that the thermal behaviour of building materials had much impact on the expected comfort and productivity of the occupants.

The building fabric is designed to shield the effect of the exterior environment from the interior environment and provide comfort for the occupant. The optimization of thermal comfort is achieved by designing the fabrics to absorb and reflect heat in the form of heat gain and later dissipate the accumulated heat into the surrounding environment (Abdulkareem, 2016; Qaid *et al*, 2016). The solar radiation that is absorbed into the interior environment increases the surface temperature of the materials and then the adjacent air temperature of the environment. For optimum conditions in the hot regions, highly reflective, low conductive materials and non-hygroscopic (non-absorption of moisture) materials like lightweight concrete fabric materials is recommended to minimize the effect of solar radiation in buildings (Latha, 2015; Obi-George *et al*, 2024). Kalamees *et al*. (2009) inferred that rooms with hygroscopic surfaces had indoor relative humidity with high variations. Su *et al* (2022) noted that at to preserve building materials from mould growth, the indoor relative humidity should be controlled below 80%. Unregulated relative humidity is the reason materials absorb moisture that causes swelling of materials that finally results to weakening and cracking of the materials. More so, as buildings get old and are in constant use, the wall elements get old and begin to lose their quality and may not function as expected due to defects in the components.

Polh (2011) also identified temperature as one critical factor that should be described, which is determined by the climate of the area. Since there are varying climates among countries with varying climatic conditions, varying thermal environmental conditions are also expected.

When the air temperature is very high, it affects the thermal environment thus making the user experience high skin temperatures. The high skin temperature triggers sweating and the sensation of dissatisfaction of the occupant with the thermal environment. ASHRAE (2020) observed that the existence of thermal comfort can be established when a substantial majority (more than 80%) of the occupant's express satisfaction with the thermal environment. The temperature of a material surface is affected by the high temperatures from solar radiation, and later affects the indoor air temperature of the space. The indoor air temperature can be increased when there are cracks in the materials which hinders the functional performance of the building fabric. When this happens, the building fabric may not be able to reflect or absorb heat effectively to optimize the air temperature of the building efficiently. Wang et al, (2010) noted that the recommended temperature range as recommended by international standard is between 24^{o}C and 28^{o}C.

Theoretical Framework

The study adopted the adaptive comfort theory and the operant conditioning theory that was proposed by Burrhus Frederic Skinner (1904 – 1990) in 1938. The theories emphasize the relationship that exists between the occupants, and the built environment that builds on continuous changes to the environment and the occupants' behaviours. According to Humphreys and Nicole, (2002), if changes that can produce discomfort occur, then people will try to adjust by doing things that will try to restore their comfort state. Humphreys et al (2007) reported that the adaptive model can touch on many topics like climatology, the design and construction of buildings, the provision and use of thermal control system, as it concerns the whole range of actions people will resort to for their comfort. The operant conditioning also looks at the events that take place before any target behaviour is noticed and events that comes after any target behaviour in an environment (Fritze, 2019; Leeder, 2022). The theory studies the relationship that exists between the environment, human behaviour, and outcome of the human behaviour. When an environment is observed to be uncomfortable, this condition triggers specific target behaviour from the occupants to seek for comfort. Relating this condition to the current study, it is believed that poor state of the lecture theatre building fabrics can create a negative environment that affects thermal performance of the building leading to thermal discomfort. A change therefore, will be required to restore this thermal performance of the building by improving on the poor conditions of the building elements.

Study Area

The research focused on tertiary institutions within Owerri Capital Territory, Imo State, Nigeria. Nigeria, located in West Africa, spans from 4^{o} to 14^{o} northern latitudes and 3^{o} to 15^{o} eastern longitudes (National Communications, 2003; Oguntunde, 2011). The country shares borders with Niger, Chad, Cameroon, and Benin, encompassing 923,769 square kilometres and housing over 211 million inhabitants (National Population Commission, 2006). Figure 1 illustrates Nigeria's map, highlighting Imo state and its neighbouring states: Abia, Anambra, Ebonyi, Enugu, and Rivers.

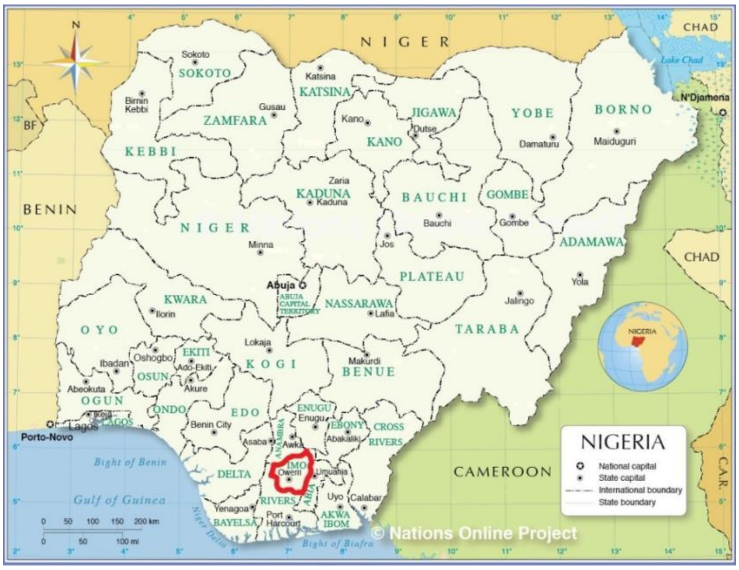

Figure 1: Map of Nigeria showing Imo State
Source: Nations online project, (2021)

Owerri Capital Territory comprises three local government areas - Owerri municipal, Owerri North, and Owerri West - along with portions of Aboh Mbaise, Ngor Okpala, Mbaitoli, and Ohaji/Egbema (Agoha, 2017). Spanning roughly 100 square kilometres, Owerri had a population of about 750,000, projected to reach approximately 1,401,873 by 2016 (National Population Commission, 2006). The Otamiri River borders the study area to the east, while the Nworie River lies to the south (Acholonu, 2008). Figure 2 depicts Imo State, pinpointing Owerri Capital Territory (cited in Amangabara, 2015).

The climate of the study area falls under the tropical wet category according to the Koppen-Geiger classification (Beck *et al*, 2018; Echebima, *et al*, 2019). Seasonal temperature variations occur between dry and wet periods. The dry season features hot, muggy, and predominantly cloudy conditions, while the wet season is characterized by warm, oppressive weather with overcast skies (weather spark, 2024). Selemo, *et al* (2012) noted that ongoing climate change, similar to other African regions, causes constant fluctuations in climatic and weather patterns.

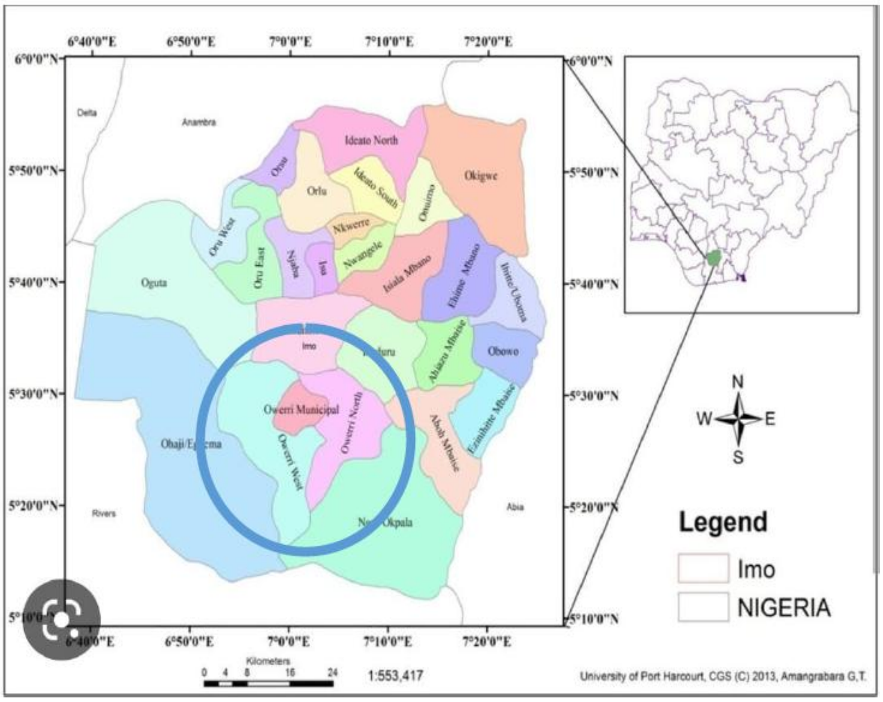

Figure 2: Map of Imo State showing Owerri Capital Territory

Source: Adopted from Amangabara, et al, (2015)

Owerri Capital Territory experiences mean annual temperatures between 28.50°C and 29.80°C, with a climatological normal of 28.32°C, increasing steadily at 0.17°C annually (Selemo, *et al,* 2012). Agidi, *et al*, (2022), and Akagha, *et al*, (2021) reported an annual relative humidity of 75% and precipitation of about 2,412mm for the area. Rainfall follows a bimodal distribution pattern, with annual averages ranging from 1,641.5 mm to 2,914.6 mm, and a calculated mean of 2,346.0 mm (Selemo, *et al,* 2012). The rainy season spans April to September, peaking in June, July, and September. Owerri Capital Territory's topography is divided into high, medium, and low areas (Ike & Eludoyin 2013; Okorie *et al*, 2019). The majority of the communities are low areas averagely below 70m above sea level. The study area belongs to the high population density of Imo State with a population density of 813.54 persons per square kilometre (AC-Chukwuocha *et al*, 2017). The institutions studied are:

i. Federal university of technology Owerri
ii. Alvan Ikoku Federal university of education, Owerri
iii. Federal polytechnic Nekede, Owerri
iv. Imo State University, Owerri.

METHODOLOGY

The research employed a quantitative survey methodology, utilizing a cross-sectional approach for data collection. The data gathering process was conducted over a specified three-month period (June, July, and August), with the research instrument administered once during this time frame. The study utilised two primary research tools: a structured questionnaire to evaluate occupants' thermal sensation and an observation schedule to assess building fabric conditions. The condition of the external and internal walls, doors and window as well as wall finishes were compressed into a composite variable as condition of the wall elements. This composite variable was germane to show a true representation of all variables for the condition of wall elements. Occupants' thermal sensation was measured using the seven-point ASHRAE scale, ranging from cold to hot, while building condition assessments were based on a five-point scale from very poor to very good (Yau, 2011; Yacob, 2016). The study population comprised all 500-capacity lecture theatres within Owerri Capital Territory, located in FUTO, POLYNEK, IMSU, and ALVAN. A comprehensive list of these 500-capacity lecture theatres across the four tertiary institutions in Owerri Capital Territory is presented in Table 1.

Table 1: List of 500-capacity lecture theatres as distributed in each tertiary institution in Owerri Capital Territory

	Tertiary institutions with 500-capacity lecture theatres			
S/N	**Federal University of Technology Owerri (FUTO)**	**Federal Polytechnic Nekede (FEDPONEK)**	**Imo State University Owerri (IMSU)**	**Alvan Ikoku Federal University of Education (AIFUE)**
1	Petroleum Lecture Theatre (PLT)	Business College Lecture Theatre (BCLT)	Law Faculty Lecture Theatre (LFLT)	Arts Lecture Theatre (ALT)
2	Hall Of Mercy Lecture Theatre1 (HMLT1)	School of Industrial And Applied Science Lecture Theatre (SIASLT)	Social Sciences Lecture Theatre (SSLT)	
3	Hall Of Mercy Lecture Theatre2 (HMLT2)	Mass Com Lecture Theatre (MCLT)		

Source: (Fieldwork, 2024)

Following this stratification, random sampling by balloting was carried out. Table 2 shows the selected lecture theatres from the pool of the lecture theatres as they contributed to the sample pool and the number of users for each lecture theatre.

Table 2: Student population as contributed by each tertiary institution

Institution Name	**(FUTO)**		**(FEDPONEK)**		**(AIFCE)**	**(IMSU)**	**Total**
Lecture Theatre (LT)	Hall of Mercy Lecture Theatre1	Hall of Mercy Lecture Theatre 2	Mass Com Lecture Theatre	SIAT Lecture Theatre	Arts Lecture Theatre	Social Sciences Lecture Theatre	
Number of students	**272**	**486**	**410**	**240**	**280**	**530**	**2,218**

Source: (Fieldwork 2024)

The number of respondents was calculated using the Cochran formular as shown in equation 1.

$$n = \frac{Z^2 \times \sigma_p^2 \times N}{(N-1)\, e^2 + Z^2 \times \sigma_p^2} \quad \text{.............................. Equation 1}$$

Where: n = size of sample for finite population; N = research population = 2,218 users; σp = standard deviation of population assumed = 0.5; e = significance level (precision/acceptable error) chosen = 0.05; Z = standard variate at a given confidence level = 1.96 for a confidence level of 95% (Kothari, 2004). The sample size of 328 respondents was calculated broken down further to the sampled lecture theatres in the ratio of their contribution as shown in Table 3.

Table 3: Student population as contributed by each tertiary institution

Institution Name	(FUTO)		(FEDPONEK)		(AIFCE)	(IMSU)	Total
Lecture Theatre (LT)	Hall of Mercy Lecture Theatre1	Hall of Mercy Lecture Theatre 2	Mass Com Lecture Theatre	SIAT Lecture Theatre	Arts Lecture Theatre	Social Sciences Lecture Theatre	
Number of students	272	486	410	240	280	530	2,218
Number of sampled student	40	72	61	36	41	78	328

Source: (Fieldwork, 2024)

RESULTS

Condition of walls

This variable was a composite of four related, similarly calibrated variables, namely State of repair of walls, Condition of Windows, Condition of Doors, and Condition of finishes. The result of the analysis of each of these is presented thus:

State of repair of walls

Data analyses showed that respondents in the category of poor condition recorded the highest number of responses (49.1%) followed by good, neutral, very poor and very good respectively. This is illustrated in Table 4.

Table 4: Aggregated data on Condition of Walls

Value label	Frequency	Valid percentage	Cumulative percentage
Very poor	18	5.5	5.5
Poor	161	49.1	54.6
Neutral	34	10.4	64.9
Good	102	31.1	96.0
Very good	13	4.0	100.0
Total	328	100.0	

Source: (Fieldwork, 2024)

Condition of windows

When checked on the number of responses on the perception of condition of windows, responses for the poor category scored the highest number of response (42.1%) followed by good (34.5%), neutral (11.6%), very poor (11.3%) and very good (0.6%) in order. This is illustrated in Figure 3.

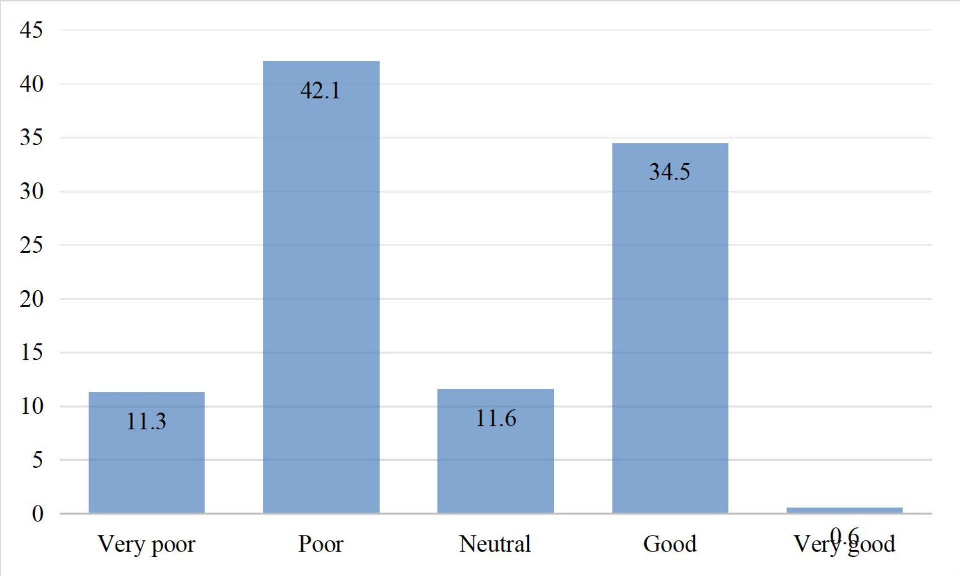

Figure 3: Aggregated data on Condition of Windows
Source: (Fieldwork 2024)

Condition of doors

Analysed data on the perception of condition of doors showed the category for good condition of doors had the highest number of responses followed by very poor, poor, good, and neutral respectively. This is depicted in Figure 4.

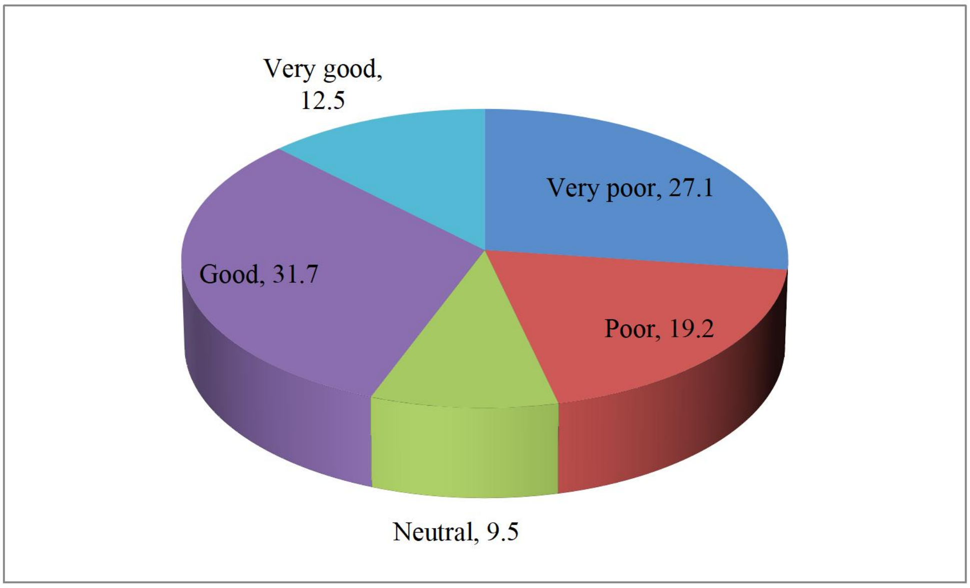

Figure 4: Aggregated data on Condition of Doors
Source: (Fieldwork, 2024)

Condition of finishes

The result from the perception of condition of finishes on wall showed that majority of wall finishes had poor conditions, followed by good condition, neutral, very poor and very good categories respectively. This is illustrated in Table 5.

Table 5: Aggregated data on Condition of Finishes

Value label	Frequency	Valid percentage	Cumulative percentage
Very poor	18	5.5	5.5
Poor	160	48.8	54.3
Neutral	59	18.0	72.3
Good	90	27.4	99.7
Very good	1	0.3	100.0
Total	328	100.0	

Source: (Fieldwork, 2024)

Thermal Sensation Votes of occupants

When evaluated on the perception of Thermal Sensation, the responses were varied among the categories. Respondents for neutral response had the highest number of responses representing 22.9% of the total vote cast, followed by slightly warm (16.8%), slightly cool (16.5%), hot (8.5%) and cold (6.4%) respectively. This is illustrated in Figure 5.

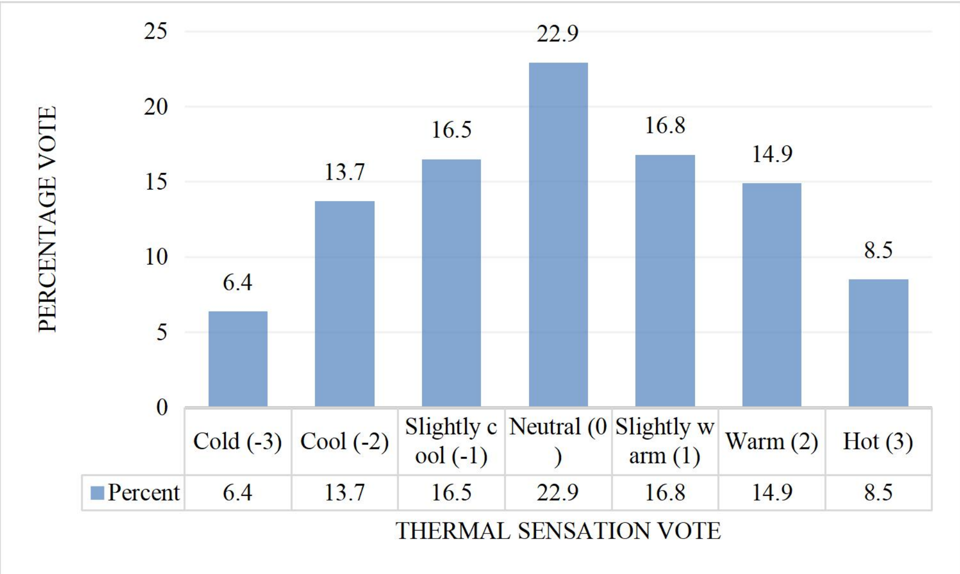

Figure 5: Aggregated data on Thermal Sensation Vote
Source: (Fieldwork, 2024)

Test of Hypothesis:
A test was conducted to determine the nature of relationship between condition of wall elements and thermal sensation votes using the Biserial correlation analysis tool.

Biserial Correlation of analysis of relationship between Condition of Wall Elements (CWE) and Thermal Sensation of Users

The Biserial correlation test showed a Pearson Correlation coefficient value of -0.161, and a significance probability value of 0.003. This implies that a relationship exists although it is a weak and negative relationship. The significance value of 0.003 indicates that the relationship is statistically significant as shown in Table 11. It can be inferred that there is a weak negative relationship between the variables and the relationship is also statistically significant.

Table 6: Biserial Correlation of analysis of relationship between CWE and TS of Users

		Thermal Sensation Vote
Condition of Wall elements	Pearson Correlation	-.161**
	Sig.(2-tailed)	.003
	N	327

Source: (Fieldwork, 2024)

DISCUSSION OF FINDINGS

From the analysis of data gathered the following findings were made:

It was statistically proven that there was a significant relationship between condition of wall elements and thermal sensation vote in the lecture theatres in tertiary institutions in Owerri Capital Territory. This, therefore, gives an indication that state of the wall elements affects the way the occupants perceive the thermal environment in the lecture theatres. This corresponds with the findings of Umeora and Ike (2021), Olotuah (2006) that noted that the state of repair of building fabrics is an essential factor for occupants' comfort.

Additionally, investigating the state of the wall elements in important in predicting how the environment affects the comfort of the occupants.

RECOMMENDATION

The study recommends the following:

i. Use of good quality building materials with low moisture absorption and high durability properties is highly recommended for the building elements and finishes. This ensures that the building elements maintain good conditions while still in use like keeping away moisture accumulation that causes unstable humidity that ends up weakening the fabrics and creating uncomfortable conditions.

ii. The buildings should be regularly appraised by facility condition assessors to ascertain the condition of the facilities. When necessary, repairs and maintenance actions should be carried out as corroborated by Maduka and Umeora (2024).

CONCLUSION

The study looked at the condition of the wall elements as a factor that can affect the thermal sensation of the occupants in the lecture theatres. The wall elements which is an integral part of the building fabric helps to regulate temperature and minimise heat transfer in buildings. The problem arises when the wall elements fail in their functional requirement to serve the intended purpose. The study was based on the adaptive comfort theory which posits that there are complex relationships existing between an individual and the immediate environment. The analyses of data gathered from the survey established that the building fabrics where in poor conditions. Similarly, the occupants' negative response to the thermal environmental condition also explained the fact that there was a significant relation between the condition of wall elements and thermal comfort of the occupants. This relationship was statistically tested using the Biserial correlation analysis tool that showed a significance probability value of 0.003 and a weak correlation value of -0.161. The study concluded that in achieving thermal comfort considering the condition of the wall elements, the buildings should be regularly appraised by facility condition assessors to ascertain the condition of the facilities and making the right choice of materials for the finishes.

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