



Post-Occupancy Evaluation of Users' Perception of Thermal Environment in an Office Building in a Tropical Climate



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Abstract	Article History
<p>High or low indoor temperatures can negatively impact the health and productivity of office workers. This study adopted the Post Occupancy method to investigate users' perception and adaptive actions in a naturally ventilated office building in the tropical climate. Approximately 244 responses were collected from 89 staff members from Alex Ekwueme Federal University, Ndufu-Alike, Ebonyi State. A questionnaire on users' perception towards indoor environmental variables was administered during the rainy season, a period when users' perception of the indoor environment is usually not thoroughly investigated. As the questionnaires were administered, the indoor and outdoor thermal variables were simultaneously measured with data loggers. Results indicate significant dissatisfaction with indoor temperatures (70% generally dissatisfied, 24% generally satisfied) when the mean indoor temperature recorded was low (27.8°C). Occupants preferred warmer environments, with majority of the staff (51%) choosing closing window as an adaptive action due to cold temperatures. The findings highlight the importance of knowing users' perception of the indoor environment and occupant behavior. Prioritizing occupants' thermal comfort in naturally ventilated office buildings, by incorporating adaptive design elements and providing occupants with control over their thermal environment, is recommended. By implementing these recommendations, building designers and operators can improve occupants' thermal comfort, productivity, and job satisfaction, ultimately contributing to a healthier and more productive work environment.</p> <p>Keywords: Buildings, occupants, post-occupancy evaluation, offices, productivity</p>	<p>Received: 15 Nov 2025 Accepted: 08 Dec 2025 Published: 12 Dec 2025</p>  <p>Scan the QR code to view*</p> <p>License: CC BY 4.0*</p>  <p>Open Access article</p>
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1. Introduction

Our indoor spaces are becoming more and more overheated because of climate change. Building interiors (or indoor spaces) refer to the spaces enclosed within a building's frame (walls, floors, ceilings/roofs). They constitute a very important part of a building's architecture, as they house spaces that support private, public, residential, commercial, cultural, religious, educational, entertainment, and recreational purposes. Interior spaces also protect building users, shielding them from harsh weather conditions, serving as focal points for work and creativity, as well as offering ambient atmosphere for building users to relax and unwind after burdensome days (Obakin & Oladunmoye, 2021). Buildings play a substantial role in this energy challenge. The world's built environment accounts for approximately one third of all global greenhouse gas (GHG) emissions whilst consuming 40% of the world's energy. Operational energy use from buildings accounts for approximately 26% of global energy-

related emissions and 30% of total energy consumption. (Chiang & Calautit, 2025). Relevant data show that, in commercial buildings, approximately 50% of the energy demand is used to support indoor thermal comfort conditions (Nicole and Humphreys, 2002). Some buildings are often constructed with limited consideration for thermal performance, leading to high energy demands for cooling (Kajjoba et al, 2022). Taiwo et al, opined that incorporating high biophilic elements in design provides substantial benefits over non-biophilic designs. Therefore, designing residences with biophilic features can greatly enhance comfort in buildings (Taiwo et al, 2025). Buildings are major energy consumers and have a great impact on the environment (Kajjoba et al, 2022; Munonye et al, 2021). A significant amount of global energy is expended to meet the cooling requirements in buildings. Apart from building, the environment also plays a critical role in determining the energy consumption of a building.

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Buildings consume vast quantities of raw materials and energy, which result in significant negative impacts on the environment (Udomiaye et al, 2018). Reduction in energy consumption reduces costs of energy, resulting in a financial cost saving to consumers if the energy saving offsets any additional costs of implementing an energy efficient technology or material. Reducing energy consumption is also a means of reducing greenhouse gas emissions (Obakin, 2018). Poorly sited and shoddy-designed buildings are factors that generate energy use in buildings. There has been a huge shift from naturally ventilated buildings to air-conditioning because of an increase in extreme heat incidents in cities. Studies show that reducing cooling energy consumption significantly is possible by applying passive approaches in buildings (Kaushal et al, 2024).

A healthy and comfortable indoor space is vital for boosting office workers' productivity and overall well-being. Gender, age, and individual characteristics influence thermal comfort perception among office workers. When office workers experience thermal discomfort, it results in reduced productivity and can also lead to illness. Conversely, employee satisfaction leads to the enhancement of productivity, comfort, and neutral health (Meir et al, 2011). Cold air affects the normal protective function of the respiratory tract, with increased bronchoconstriction, mucus production and reduced mucus clearance (Camprubi et al, 2016). It is therefore important to carry out post evaluation on the existing structures to know the solutions to their deficiencies so that problems of such can be avoided in the future. Cold damp houses also promote mold growth, which increases the risk of respiratory infection (Fillippin et al, 2024).

The post-occupancy evaluation (POE) is an overview of the architectural and technical performance of the building during its use. It is a method that is used to evaluate an occupied building during its typical use, with the aim of better understanding the disparities between predicted and thermal comfort performances. In practice, POE has been applied to numerous commercial and residential projects (Hemeen, 2020). The most common reasons for POE are to fine-tune a new building for maximizing occupants' wellbeing and productivity, to inform designers and contractors about the actual performances of their 'product', to establish benchmark data, to improve certification schemes, and to support the investment decision process. University buildings are capital intensive investments that should be regularly evaluated to ascertain its service quality because one argues that a workplace of good quality promotes quality life (Ikediashi, et al, 2020).

To assess the thermal comfort of a group of people, two models are popularly adopted. The first model is the Heat Balance Model (HBM) which uses the Predicted Mean Votes (PMV) as an index to define acceptable indoor environments. The HBM is also called a steady-state or a rationale model, and it is a laboratory experiment where the subjects do not have control over six factors (four environmental factors and two personal factors). The environmental factors are; Air temperature, mean radiant temperature, Air velocity, and Relative humidity while the personal factors are; Activity rate and Clothing insulation By prioritizing thermal comfort,

offices can promote worker well-being and reduce energy waste.

Indoor thermal comfort can be achieved by adjusting the environmental conditions through the Heating Ventilation and Air Conditioning (HVAC) System, or using personal comfort system (Song et al, 2016). However, HVAC's consume a lot of energy and causes environmental pollution (Munonye et al, 2021). Using personal comfort system is effective, environmentally friendly and a cheap method to achieve thermal comfort. Thermal comfort can be assessed by adopting both objective and subjective procedures. The objective procedure involves the use of measuring instruments to record the environmental parameters while the subjective procedure involves using a questionnaire to collect data about how the subjects feel about the internal environment (Munonye, et al, 2023). Comfort vote is one of the indicators used to assess the thermal perception of building occupants.

At present, most of the research on the thermal environment of indoor buildings in the tropics is still concentrated during the warm seasons. Only few studies were carried out during the rainy seasons. Thermal comfort is effected by both the warm and cold seasons. There is a need to provide further information about the thermal comfort of building occupants during the rainy season. The aim of this paper is to conduct a POE in a faculty of humanities building in a university setting during the rainy season in order to identify the rate of user satisfaction and dissatisfaction with the indoor thermal environment, and to provide insights for future design improvements. POE has become one of the important methodologies in assessing building performance, providing a framework to examining occupied buildings to derive lessons that will enhance their operational conditions and inform future design practice (Kim et al, 2013; Mei et al, 2009, Baharetha. et al, 2025). Building occupants are valuable source of information on building performance as well as indoor environmental quality and their effects on comfort and productivity (Aliyu et al 2016). As thermal comfort is a critical aspect of occupant satisfaction and operational success, POE enables direct feedback from users, making it particularly well-suited for evaluating indoor environmental quality in real-world contexts. (Baharetha. et al, 2025). The current paper sets out to furnish additional information based on field experiments in the humid tropics.

2. Literature Review

2.1 Thermal comfort

Thermal comfort is achieved when the heat generated by human metabolism is allowed to dissipate, maintaining thermal equilibrium with the surroundings. Thermal comfort refers to the condition of mind that expresses satisfaction with the thermal environment (ASHRAE (2017)). Several factors influence thermal comfort. These are personal, environmental, cultural and social factors. Personal factors consist of metabolic rate, age and acclimatization. Environmental factors are air temperature, mean radiant temperature, relative humidity and air velocity.

Studies have shown that temperature fluctuations can impact thermal comfort, particularly in non-air-conditioned buildings. Research has also found that seasonal temperature variations

can influence thermal comfort (Munonye, 2020). As such, understanding these variations is crucial for designing and operating buildings that provide optimal thermal environments for occupants. Comparable temperature levels might be influenced by factors such as building orientation, window and roofing design, and shading efficiency (Maduabum & Munonye, 2025).

Furthermore, thermal discomfort can be caused by unwanted local cooling or heating of the body or by hot or cold discomfort of the body as a whole. Air movement can also cause unwanted local cooling of the body caused by draught (ISO 7730; 2025).

Thermal comfort studies have been carried out in buildings in Nigeria in both naturally ventilated buildings and air-conditioned buildings with a temperature range between 21 - 30 °C. According to Perez-Lombard et al (2008), office buildings are those with the highest energy consumption and the highest CO₂ emissions among commercial buildings. In offices, a comfortable indoor environment increases workers' productivity (Efeoma, 2016; Adebamowo et al, 2013; Jimoh et al, 2020; Musa, 2024). Awada and Srour (2018) investigated the occupants' satisfaction with indoor environmental quality in office buildings. Results indicated that the distance of employees from windows affected their satisfaction and productivity. These studies produced a different range of temperatures and adaptive actions. To achieve comfortable indoors, architects need to consider the climate of the locality from the initial stage of design (Munonye et al, 2021).

Thermal dissatisfaction is one of the most common complaint sources of the indoor environmental quality (IEQ) of office buildings in different climates. Thermal discomfort is not just a lack of satisfaction with the ambient temperature but reflects a situation where there is a potential threat to health. Thermal discomfort can be caused by cold or warm indoor temperatures.

2.2 Adaptive behaviour

Adaptive behaviour to thermal comfort refers to how people take some actions to stay comfortable in varying temperatures in the environment they encounter. Occupants' behaviour and thermal comfort are closely linked, as occupants' action can significantly impact their thermal satisfaction and the energy consumption of buildings. Adaptive abilities act at three levels: Physiological, psychological and behavioral. Comfort perception varies across individuals due to these three factors, resulting in different responses. Physiological factors of adaptation include comfort expectations, age, gender and health of the occupants. Psychological factors include comfort expectations, safety concerns and habit. Studies have shown that occupants tend to adapt to their thermal environment through various behaviours such as adjusting clothing, using fans or closing windows. For example, drinking hot or cold water through adaptation, one may add extra layers of clothing when feeling cold or remove extra layers when feeling warm or hot (Munonye, 2020). Dress code, work style and social norms are the components of cultural and social factors. When people are not free to adjust their clothing because of a dress code, and adaptation is hindered and may provide thermal discomfort to such occupants (Efeoma, 2016). People's

attitudes toward adapting to their environment are influenced by the availability of adaptive options. Cloth changing has been the most adaptive action adopted by indoor occupants to restore comfort (Kajjoba et al, 2022). Air speed has an influence on the adaptation of building occupants. According to ASHRAE standard, if sedentary office occupants do not have control over the local air speed, the upper limit to air speed should be 0.8 m/s for operative temperatures above 25.5 °C. (Cui et al., 2013).

Adaptive behaviours are particularly significant, as they are widely recognised for their substantial impact on buildings' energy performance. Adaptive models rely on the ability of occupants to adapt to changes in their thermal environment in such a manner as to restore their comfort. Adaptive model considers people as an active part of the thermal environment because factors beyond the mere passive experience of a body's thermal balance play a significant role in determining human thermal preferences. Psychological, physiological, and contextual environmental factors determine how frequently occupants adopt a particular adaptive option.

3. Methods

Post occupancy evaluation (POE) is the assessment of the building when it has been occupied. Data was gathered by the use of questionnaire, measurement of indoor environmental variables and observations. SPSS software was used to analyze the data.

3.1 Location and climate

The study area is situated in Ikwo Local Government Area of Ebonyi State with Abakaliki as the capital. Abakaliki lies between Latitude 06° 25' N and longitude 08° 3' E and altitude of 170 m and has humid tropical climate. The rainfall ranges from 1700 to 2000 mm with mean annual rainfall of 1800 mm (ODRNI 1989). The study area experiences two seasons: A short dry season and a long wet season. The dry season commences in November/December to March of the following year, while wet season commences mostly in February/March till late October. The mean annual temperature ranges from 27 to 31 °C throughout the year. The relative humidity is high, 80% during rainy season but declines to 65% in the dry season (ODRNI 1989).

3.2 Field measurement

This study adopts post-occupancy evaluation (POE) to assess occupants' level of satisfaction with naturally ventilated conventional office buildings in a tropical climate in, Nigeria. Users' perception towards indoor environmental variables can be determined in occupied office buildings (Abass et al, 2020).

The POE was conducted in faculty of humanities building AE-FUNAI, where staff work from Monday to Friday, between the hours of 8am to 4 pm. The offices have two distinctive sizes. An office with an area of 13.0 m², occupying 2 people, while a bigger office space of 20.0 m² accommodates 3 people. The surveyed offices have the same orientation and are built of the same material. Figure 1 shows some views of the faculty of humanities building

A mixed-method research approach that combines quantitative and qualitative methods was adopted. Structured and semi-structured questionnaires were administered to determine their level of satisfaction or dissatisfaction with the indoor thermal conditions. The users' satisfaction design ranged from 'very dissatisfied' to 'very satisfied' as shown in Table 1. Further questions were asked, requesting the participants to indicate the adaptive actions they embark on and the reason for choosing the adaptive action.

The Tiny Tag Ultra 2 Gemini Logger was at 1.2 meters above the floor level and away from the impact of the sun. The logger measured the indoor air temperature, while the Wet Bulb Globe Temperature (WBGT) Heat Stress Meter measured the globe temperature. These instruments met the prescriptions of ASHRAE standard (ASHRAE Standard, 2017; Hayatu et al, 2015). Kestral 3000 pocket wind meter measured air speed at various sports in the surveyed offices.

Table 1: Users' satisfaction scale and adaptive actions

Comfort scale	Adaptive action(s)	Reason for adaptive action (s)
Very dissatisfied	Drink cold water	Very hot temperature
Dissatisfied	Drink hot water	Warm temperature
Slightly dissatisfied	Open window	Cold temperature
Neutral	Close window	Very cold temperature
Slightly satisfied	Remove extra clothing	Too much air movement
Satisfied	Add extra clothing	Little air movement
Very satisfied	Walk around	No air movement
	Use hand fan	
	Any other (Specify)	



Figure 1: Views of the faculty of humanities building

3.3 Sample size

A sample size of 89 was obtained from the faculty population (staff) of approximately 114 using Taro Yamane formula (Equation 1) with 95% confidence level.

$$\text{Equation 1} \quad n = N / (1 + Ne^2)$$

where,

n = sample size

N = population size

e = margin of error (acceptable error level, often expressed as a decimal)

This sample size comprises of male and female workers of various age range. The 89 sample size gotten was then randomly selected from the population. All respondents maintained a sitting position while filling the questionnaires.

Their metabolic rate was assumed to be within the range 1.0 and 1.3 met according to ASHRAE 55(ASHRAE, 2017).

4. Results and Discussion

4.1 Study sample characteristics

As shown in Table 2, 244 responses were obtained from 89 staff during the three day survey. The demographic data shows that 18.9% and 81.1% of the staff were teaching and non-teaching, respectively. The mean age of the participants is 42 years with more than half (54.5%) of them within the age range of 49-59 years. More than 80% of the participants were within the age range 37-59 years. None of the participants was less than 26 years or more than 59 years.

Table 2: Demographic characteristics of respondents

	Perc (%)	Responses Total (n=244)		Morning Responses (n=118)		Afternoon Responses (n=126)	
		Sample size	Perc (%)	Sample size	Perc (%)	Sample size	Perc (%)
Teaching		46	18.9	14	5.8	32	13.1
Non-teaching		198	81.1	104	42.6	94	38.5
Age years	<26	0	0	0	0	0	0
	26-36	45	18.4	30	25.4	42	33.3
	37-48	66	27.1	29	24.6	21	16.7
	49-59	133	54.5	59	50.0	63	50.0
	>59	0	0	0	0	0	0

4.2 Office thermal conditions

Table 3 shows the summary of indoor and outdoor thermal variables recorded during the three days the surveys were carried out. The air temperature and mean radiant temperature were similar. The outdoor temperature was higher than the indoor temperature during the periods the surveys were conducted.

The indoor temperature recorded the highest maximum value on July 19, while the lowest maximum was recorded on Aug

5. The mean temperature on July 8 was much lower than the mean temperatures on July 19 and August 5. The rainfall that occurred on July 8 reduced the outdoor temperature, with the indoor temperature tracking the outdoor temperature. The indoor relative humidity varied between 66.6% and 91.5% during the survey. The highest mean indoor relative humidity was recorded on August 5, 2025, with the highest maximum value of 91.5%, while the air velocity varied between 0.3m/s and 1.2m/s.

Table 3: Summary of thermal variables

	All	July 8, 2025	July 19, 2025	Aug 5, 2025
Air temperature (°C)				
Min	26.5	26.4	26.8	26.7
Max	29.5	29.4	30.2	29.2
Aver	27.8	27.4	28.0	28.1
Mean Radiant temperature (°C)				
Min	26.7	26.3	26.8	26.8
Max	29.3	29.4	30.3	29.2
Aver	27.9	27.5	28.0	28.0
Outdoor temperature (°C)				
Min	27.4	27.4	27.1	27.4
Max	31.1	29.8	31.0	32.0
Aver	29.5	29.7	29.4	29.7
Relative humidity (%)				
Min	66.9	66.6	66.8	71.2
Max	73.2	70.4	71.4	77.4
Aver	90.2	85.6	90.3	91.5
Air Velocity (m/s)				
Min	0.3	0.4	0.3	0.3
Max	1.8	1.7	1.7	1.8
Aver	0.8	1.2	0.9	1.2

Air velocity averaged 0.7m/s, 0.9 m/s, and 1.1m/s on July 8, 19, and August 5, respectively. These results suggest that indoor conditions are influenced by outdoor weather, with rainfall impacting temperature and humidity levels. Air velocities are within the ranges that may cause discomfort, especially on August 5.

4.3 Staff response to the thermal environment

The result of the users' level of satisfaction with the indoor thermal variables is reflected in Figure 2. The survey results indicate a significant level of dissatisfaction with indoor temperature among office occupants. The perception tended more to the dissatisfaction zone where approximately 70% of the staff expressed general dissatisfied, while only 24% were generally satisfied. Only 16% of the staff were neither dissatisfied nor satisfied.

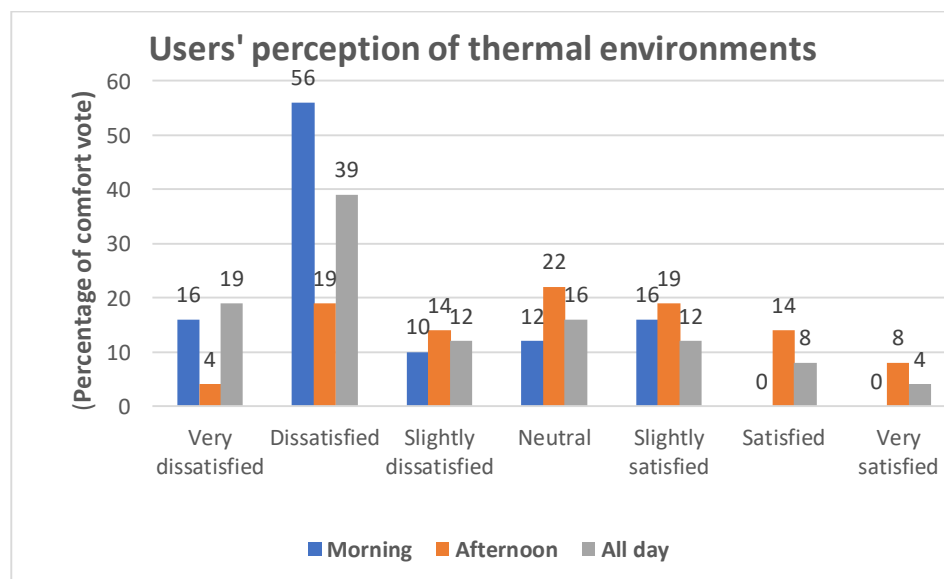


Figure 2: Users' Perception of indoor air temperature

The level of dissatisfaction was higher in the morning hours (82%) compared to the afternoon hours. Approximately 72% of the subjects indicated general dissatisfaction in the morning hours compared to the 37% in the afternoon hours. In other words, approximately 35% of the staff who were dissatisfied in the morning were satisfied in the afternoon. Furthermore, while 0% of the subjects were satisfied in the morning, 22% were satisfied in the afternoon. Approximately 12% were neither satisfied nor dissatisfied in the morning against 22% that were neither satisfied nor dissatisfied in the afternoon.

4.4 Adaptive actions

Figure 3 shows the adaptive actions taken by the staff to restore comfort when uncomfortable with the indoor temperatures. According to Adaptive Theory, people are not passive receivers of their thermal environment but alter or adapt to their environment to suit themselves, and if a change occurs that produces discomfort, people will tend to act to restore their comfort (Humphreys and Nicol, 1998; de Dear and Brager, 2002).

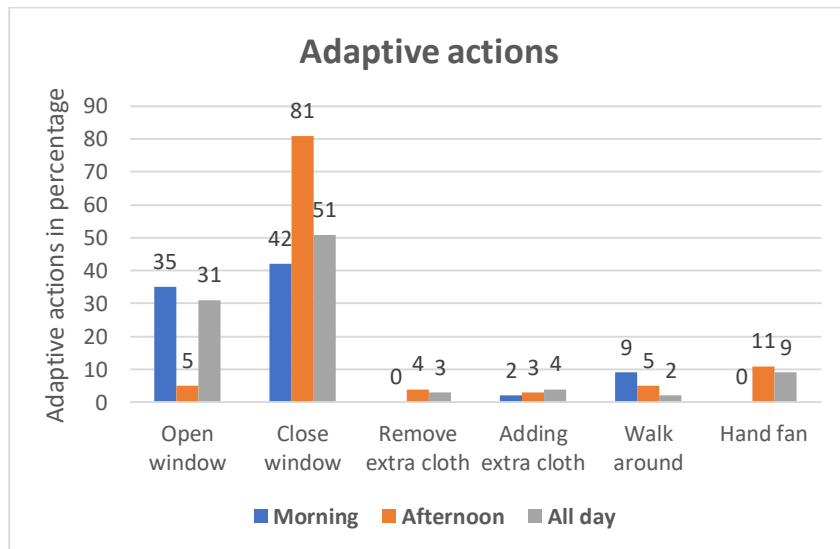


Figure 3: Adaptive actions

When the occupants were uncomfortable with the indoor temperature, most of them (51%) chose the adaptive action to “close the window”. The option to choose “open windows” as an adaptive action was more in the afternoon (81%) compared to the morning hours (42%). The reason given by most of the participants, as shown in Figure 4, was because of “cold temperatures”. Too much cold temperature (66%) was reported in the afternoon, as against 29% in the morning. From the findings of the unstructured interview, most of the staff preferred warmer indoor temperatures irrespective of the time of day. The result agrees with some previous thermal comfort

surveys in the tropics conducted in the rainy season, where office workers mostly preferred warmer temperatures. For example, Jimoh and Demghakwa (2020) conducted a study in naturally ventilated office buildings in Jos, Nigeria, in May (rainy season), where the average ambient temperature recorded was 27.16 °C. A temperature (29.4 °C) higher than the ambient temperature (27.16 °C) was obtained, with the occupants preferring a warmer indoor environment. Jimoh and Umar (2021) also found occupants in office buildings in Jos wanting to be warmer, having produced a neutral temperature of 28.71 °C at midday.

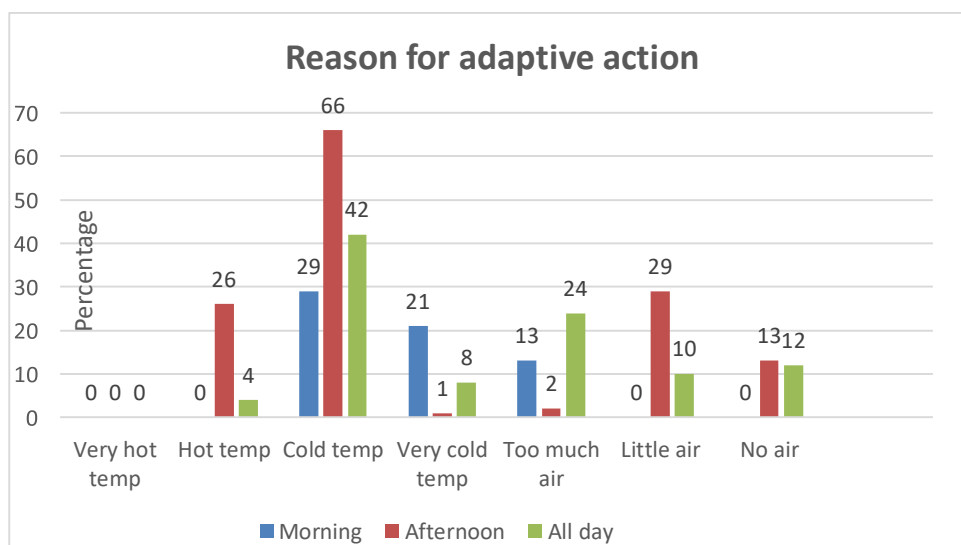


Figure 4: Reasons for adaptation

In the afternoon hours, a significant number (81%) preferred to “close the window,” while in the morning, 42% preferred to do the same. The mean indoor temperature recorded in the afternoon hours was low, as a result of the rain that fell, especially in the afternoon hours. The staff experienced cold thermal sensation as a result of that, resulting in their taking adaptive actions to “close the window”. Furthermore, to ward off the cold, 5% of the occupants took adaptive action of “walk around” all day.

Only 5% of the occupants took adaptive action to “open window” in the afternoon as against 35% that took the same adaptive action in the morning. The preference for more people to close the window increased significantly by (30%) in the afternoon.

Table 4: Preferred adaptive action

Drink Cold Water	Drink Hot water	Open window	Close window	Remove extra cloth	Add extra cloth	Change posture	Personal fan	Others
29%		32%		24%		2%	13%	-

5. Conclusions/Recommendations

The field study was performed in a naturally ventilated humanities faculty building located at AE-FUNAI in a humid tropical climate of Ebonyi state. A total of 89 respondents provided 244 responses during the survey.

The survey reveals interesting insights into occupants' thermal perception, adaptive actions, and preferences in response to indoor temperature during the rainy season. 51% of occupants closed windows due to cold temperatures (38%), indicating a preference for warmer environments. 24% complained of "too much air" (all day), causing cold sensations, especially during rainy periods. Only 3% added extra clothing, but 24% would prefer this option, citing forgetfulness or inconvenience. 29% preferred drinking cold or hot water, but faced accessibility issues. Many of the staff closed windows due to rain that caused reduced temperature, producing cold thermal sensations. Prioritizing occupants' thermal comfort in naturally ventilated office buildings, by incorporating adaptive design elements and providing occupants with control over their thermal environment, is recommended.

Limitations:

- The study is limited to a single faculty building in Nigeria, and the results may not be generalizable to other buildings or climates.
- The study only considers the rainy season, and the results may not be representative of other seasons.

Competing interests

The authors declare no competing interests.

Author contributions

All authors contributed to the development of this work. They have all read and approved the final manuscript.

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Furthermore, only 3% adopted “add extra cloth” as an adaptive measure all day. However, as shown in Table 4, a significant number (24%) would prefer to “add extra cloth” or “remove extra cloth” as an adaptive measure. When asked why they do not come with extra cloth some said they often forget, while some others said they consider it as an additional load as they do not come with their personal car. 29% of them would prefer to drink cold or hot water as an adaptive action. However, there was a complaint of not having these adaptive actions handy. A cursory check at these responses show that most of the staff did not take this adaptive option of “add extra cloth” or “remove extra cloth” because the options were not available to them. This is in tandem with their response to the reason for not making these available options. The effect is that their comfort was hampered.

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