EVALUATION OF THERMAL COMFORT IN SCHOOL OF ENVIRONMENTAL TECHNOLOGY COMPLEXES IN SELECTED GOVERNMENT OWNED UNIVERSITIES IN SOUTH EAST NIGERIA

EZE, Chukwudum Jasper & Okoro Emmanuel Ijioma
Department of Architecture, Federal University of Technology, Minna, Niger State, Nigeria

In School built environment, there is strong, consistent evidence of the effect of basic thermal comfort variables like indoor air quality, ventilation, day lighting, and temperature on learning. These physical characteristics affects student cognitive ability and behaviour, if not adequately considered in design can lead to a decline in understanding ability of the students thereby making them less productive in academics. The aim of this study is to evaluate the thermal comfort in school of environmental technology complexes in order to propose a design that will enhance students learning. The research methodology adopted is the mix use method focusing on evaluating the Environmental Faculty or Complex of some selected universities in the South-Eastern part of Nigeria. The research identified some architectural design Considerations that plays vital role in thermal comfort. These Ranges from; the construction methods and materials of the various parts of the building to its finishes, the number of users and sizes of space. This study have shown that physical environment and surrounding settings affects learning. Therefore this research suggest a periodical evaluation of learning spaces and consideration of components that affect learning environments as a check for school designers and owners, educators and teachers in communicating appropriate requirements for attaining student's utmost performance and Positive learning outcomes.

Keywords: School, Environment, Thermal-Comfort, Environmental-Complex.

INTRODUCTION

Thoughts, plans and decision can easily be distracted when the body does not relate or feel comfortable within the environment where it resides. The condition of the environment plays a greater role in optimizing the performance of people while undergoing a mental activity which is a full function of the mind. The mind is the root of understanding since it is the bedrock for every action which includes; thinking, reading, and writing among which education is realize. The mind according to thesaurus dictionary is that which is responsible for ones thoughts and feelings; the seat of the faculty of reason (thesaurus dictionary, 2017). Education is considered to passively begin from the womb, as the unborn child goes through some levels of discipline as the mother taps her stomach when the unborn child begins to inconvenience her causing pains in her womb. Education as described by thesaurus dictionary (2017); refers to the act or process of educating; the result of educating, as determined by the knowledge skill, or discipline of character acquired, (David et al. *2016*). Intelligence and Environment researches investigates the impact of environment on student's intelligence which is one of the most important factors in understanding human group differences in IQ test scores and other measures of cognitive ability. It is estimated that genes contribute about 20–40% of the variance in intelligence in childhood and about 80% in adult. Therefore the environment and its interaction with genes results to a high proportion of the variation in intelligence seen in groups of young children, and for a small proportion of the variation observed in groups of mature adults. Despite the fact that intelligence stabilizes in early adulthood, it is thought that the genetic factors influence more of our intelligence during middle and old age and based on that.

okoemmi@gmail.com

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The importance of the environment dissipates. The interaction of the physical leaning environment and thermal comfort has not been fully considered in the design of school of environmental technology complex in government owned universities located in eastern part of Nigerian, thereby leading to uncomfortable study environments. It is therefore important to evaluate the thermal comfort in these complexes with the view of finding the true state of the complexes in regards to thermal comfort with the use of bioclimatic approach aimed at providing suggestion to enhance students' academic output through the achievement of a thermally sustainable school of environmental complex

Thermal Comfort and the Environment

Human thermal comfort is defined by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) as the state of mind that expresses satisfaction with the surrounding environment (ASHRAE Standard 55 2013). Maintaining thermal comfort for occupants of buildings or other enclosures is one of the important goals of heating, ventilating, and air conditioning design engineers. Heat conduction, convection, thermal radiation and evaporative heat loss are affected by thermal comfort. It is maintained when the heat generated by human metabolism is allowed to dissipate, thus maintaining thermal equilibrium with the surroundings. Any heat gain or loss beyond this generates a sensation of discomfort. It has been long recognised that the sensation of feeling hot or cold is not just dependent on air temperature alone. According to Andris. and Steven ; Socrates, around 400 BC had some thoughts about climatic suitability of houses, focusing on how to build to ensure thermal comfort. The works of Vitruvius (1st century BC) also tailored towards the need to consider climate in building design, for reasons of health and comfort. This however did not have much influence on the practice of architecture hence until the Industrial Revolution. Thermal comfort was not a practical issue, as there were very few tools available to influence it. During the cold period, a fire was lit to ameliorate the conditions and when the weather becomes hot, the use of hand-held fans was the only relief, or perhaps larger fans operated by obedient servants.

Thermal comfort therefore is determined by the state of mind of an individual whether he or she is hot cold or simply comfortable in their environment (HSE 2012). However, a number of buildings use HVAC (Heating Ventilation Air Conditioning) systems to regulate their environment and achieve a thermal comfort. In recent times however, more energy efficient and environmentally friendly, methods are used to heat and cool buildings.

The major function of a building is to protect its users and indoor space from drastic weather conditions as excessive sun, wind and rainfall. But when this function is defeated, the users become thermally uncomfortable hence, they tend to find alternative sources of heating and cooling. This can be resolved by adopting climate responsive designs which will involve Natural ventilation which will reduce or eliminates the amount of mechanical systems required to cool the building if adequately designed. Temperature could either rise to be too hot or too cold depending on season of the year. Therefore, the factors below should be considered when designing to achieve good thermal comfort (omer, 2008).

1. Building orientation
2. Window sizes and location
3. Construction materials
4. Cross ventilation
5. Roof, walls and floor insulation
6. Additional cooling required during heat periods

The adopted bioclimatic approach in this research entails that every construction be adaptive to its location in terms of terrain, climate, locally available building materials and orientation of building on site, passive design principles and efficient use of ecofriendly and renewable energy systems. In order to do this, there is need to:

1. To determine the extent of thermal discomfort of in the schools of environmental technology complexes

2. To identify the possible causes of thermal discomfort in the complex

Thermal Comfort Bioclimatic Design Approach

Bioclimatic architecture as an approach to achieving thermal comfort is a term which was first used in the early sixties (60s) by the olgyay brothers. They brought into existence the bioclimatic chart which uses the psychometric chart as a basis to relate climate as strategies

to be used to determine thermal comfort of a particular location. According to kane cres (2012) as cited by Adedayo, et al. (2013), the use of micro climate of a region to provide both thermal and visual comfort for occupants with renewable energy (solar) as a means of generating electricity and geothermal system for heating and cooling is an efficient system of ecofriendly design. Building materials and passive architectural design systems are equally considered to be among the parameters. The bioclimatic design approach focuses on both interior and exterior aspects of construction which is achieved by using the vital feature of bioclimatic design to ensure quality landscape construction materials and micro climate of a place are integrated actively with the existing environment (Martinez, 2012).

The physical and chemical properties of the various materials used for construction and the methods used are important aspects of building sustainability, the building orientation, sun shading devices and size of openings needs to be considered in the design process. The sounding environment is affected by the Buildings around it during their active periods because of their necessity to heat and cool and also provide lighting needs. Earth architecture, (2012) highlighted that Materials with less CO_2 discharge should be used in construction to elongate the life span of the building. Furthermore the Energy efficient designs can reduce engaged energy costs by 75% within the life span of a building which only about 1% of its impact on the surrounding is respondent to building materials. Every area has there specific Bioclimatic design measures centred primarily on the climate of the area which can be evaluated as listed below;

1. **Building Envelope and Orientation:**

Heat gain through the building envelope needs to be reduced and prevented from affecting the interior spaces of the structure especially during the hot periods. This can be reduced by the orientation of the building and materials used for construction (Martinez, 2012). Building orientation towards the south and placement of openings is also to be considered.

2. **Landscape:**

Planting trees and incorporating artificial water bodies can also improve the micro climate of the environment.

3. **Energy Source:**

In the research publication by Kane cress (2012), it is suggested that the potentials of the sun should be used as an alternative source of energy and also for lightning up the buildings all through the year rather than depend on artificially generated energy.

4. **Sun shading devices:**

Sun shading devices like vertical, horizontal or egg-creates members can be used to reduce Heat gain into the building during periods of high temperature. Also using materials and paints that would permit less penetration of the solar rays will equally be needful to control the acceptance of heat in the buildings.

5. **indoor air quality:**

Through the use of green/living walls, indoor air quality can also be improved as this will capture airborne particles while providing oxygen to liven up spaces. Air locks can also be installed in doors as it reduces the effect of heat on the building envelope (Moon 2007).

6. **Passive design:**

Appropriate choice of window types and the use of large window openings will allow natural ventilation and accumulated heat during the day can also be given out or balanced naturally at night time.

7. **Heating and cooling:**

Ensure that materials used for glazing allow minimum solar radiation (glare and adequate light in the interior spaces.

Human Performance in Relation to the Thermal Comfort of their Environment

Rammsayer TH, et al. (1995).in a research titled "The effect of cold on human information processing: application of reaction time paradigm," discovered in thirty healthy male volunteers who performed a stimulus evaluation-response selection reaction time task after exposure to ambient temperatures of either 28 or 5 degrees C. A 0.5 degree C-decrease in

body core temperature resulted in a significant increase in both reaction and movement time indicating a general deteriorating effect of lowering of body core temperature on information processing. Mean reaction times were 538 ms and 549 ms for the control and the cold group, respectively ($p < .05$). The respective mean movement times were 298 ms and 269 ms ($p < .001$). Speed of stimulus evaluation was not sensitive to decreases in body core temperature. However, response complexity and body core temperature showed a significant interaction in their effect on movement time ($p < .05$), indicating that lowering of body core temperature is more likely to affect response-related stages of central information processing rather than stimulus evaluation. Furthermore, movement time appeared to be more sensitive to cold-induced effects on information processing as compared to reaction time. Additional co-relational analyses suggest that the observed effects can be considered as independent of changes in skin temperature and experienced levels of thermal discomfort. Taken together, the results indicate that lowering of body core temperature deferentially affects various stages of information processing.

The most serious level of temperature dysregulation is called heat stroke, and it occurs when the body's temperature reaches an excess of 104 degrees Fahrenheit. During heat stroke, body functions grind to a halt, as the hypothalamus region of the brain shuts down the body's natural coolant system, perspiration. Without sweat, the body can no longer keep its temperature in check, which causes a devastating chain reaction that can be fatal without timely medical intervention.(https://m.accuweather.com/en/weather-news/what-does-extreme-heat-do-to-the-human-body/70002105)

Study Area

South-East Nigeria has the lowest landmass compared to other parts of the country, hence a high percentage of building development is evidently covering up the whole land mass. This has necessitated some developers to neglect the allowance for soft and hard landscape within the area as most of the land owners tries to take full advantage of the land by using up all the land space during construction.

According to previous studies; in the analyses of climatic data of temperature, Rainfall and relative humidity, Nigeria is classified into four broad climatic zones the hot dry, temperature dry, hot humid and warm humid zones. The South-East Nigeria falls into the hot humid/tropical climatic zone with mean daily maximum dry bulb temperature during the dry season not less than 38°C, it has a very small temperature range. The temperature ranges are almost constant throughout the year, in some areas the maximum temperature is 28 °C (82.4 °F) for its hottest month while its lowest temperature is 26 °C (78.8 °F) in its coldest month. The temperature difference is not more than 2°C (5 °F). South-East Nigeria experiences heavy and abundant rainfall accompanied with storms at some times. These storms are usually convectional in nature due to the regions proximity, to the equatorial belt. The annual rainfall received in this region is very high, usually above the 2,000 mm (78.7 in) rainfall totals giving for tropical rainforest climates worldwide.

The study sample is the Environmental complexes of the University of Nigeria Nsuka, Enugu State (UNN), Abia State University Uturu, Abia State (ABSU) and Imo State University Owerri, Imo State (IMSU).

RESEARCH METHODOLOGY

This research featured the mix use method; the Primary data was gathered from observation of the various universities environmental complexes. This enabled both qualitative and quantitative data collation on the user's perception to assessment of thermal comfort in their various study environment. Questionnaires were used for the quantitative data, while observation of the building condition served for the qualitative information. A random sampling technique was adopted to get the required information. The population samples for this research were taken from different departments in the environmental complex, 25 persons from each study area and questionnaires were administered to gain data on the thermal conditions of the complex, possible thermal discomfort if any exist, and the possible causes of discomfort to the users.

DISCUSSION OF FINDINGS

The field survey enhanced the quality of information gathered on the physical form of the buildings. The environmental complexes of the universities in South-East Nigeria have been identified to pose significant level of thermal discomfort to users. Based on a research work of Adedayo et al. (2012); major criteria for assessment of thermal comfort was derived, these are

a. Orientation of building on site to face the north-east and south-west to allow minimum solar radiation into the building.
b. Provision of wider sizes of openings to allow maximum natural ventilation into the building.
c. Use of natural building materials such as bricks, compressed earth blocks for the construction of building envelopes.
d. All openings that allow ventilation such as windows and doors should face directly to an outdoor environment without obstruction to achieve maximum ventilation into the buildings.

The plates below shows the researchers findings in the study areas.

Case Study 1,
Abia State University Uturu (ABSU)

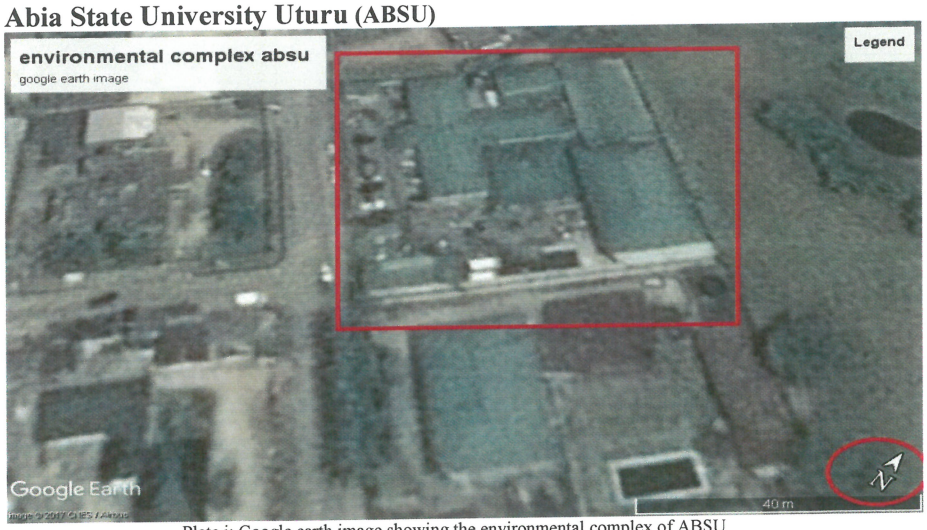

Plate i: Google earth image showing the environmental complex of ABSU
Source: Google Earth Map (2017)

Plate ii: View of the class room showing ceiling material
Source: Author's field work (2017)

Plate iii: View of the courtyard
Source: Author's field work (2017)

Case Study 2,
Imo State University Owerri (IMSU)

Plate iv: Google earth image showing the environmental complex of IMSU
Source: Google Earth Map (2017)

Plate v: View of the lobby between class rooms
Source: Author's field work (2017)

Plate vi: View of the courtyard
Source: Author's field work (2017)

Case Study 3,
University Of Nigeria Nssuka, Enugu State (UNN)

Plate vii: Google earth image showing the environmental complex of UNN
Source: Google Earth Map (2017)

Plate viii: View of the courtyard
Source: Author's field work (2017)

Plate ix: View of the class room area
Source: Author's field work (2017)

The complexes seen in the case studies on plates i,iv and vii above shows a reasonable compliance to the orientation criteria of buildings on site to face the north-east and south-west direction to allow minimum solar radiation into the building. Plates ii, vi and ix shows Provision of wider sizes of openings to allow maximum natural ventilation into the building but a major flop was discovered on the type of windows provided. The plates shows the presence of sliding windows. Sliding windows reduces the amount of ventilation inlet into the interior spaces because only a part of it can be opened at a time. Plate iii, vi and viii shows the presence of courtyard in all the case studies. Plate v shows that some of the windows on part of the complex on case study 2 do not have direct access to open space or the courtyard. The Use of natural building materials such as bricks, compressed earth blocks for the construction of building envelopes were considered.

Based on the author's field survey, it was discovered that case study 3 considered the major bioclimatic criteria in the design while they were not fully considered in case studies 1 and 2, hence a questionnaire was distributed to the students and staff to obtain their feelings of thermal comfort within the complex. This was targeted to finding users thermal perception of the complex not minding the design inability to fully conform to the major bioclimatic criteria.

Table 1.0: Users Rating of Thermal Comfort in the Environmental Complex

Institution	Hot	Cold	Normal	Warm	Too Cold	Total
ABSU	**9**	**0**	**12**	**4**	**0**	**25**
IMSU	**8**	**0**	**5**	**12**	**0**	**25**
Sub- Total	17	0	17	16	0	50

Source: Author's field work (2017)

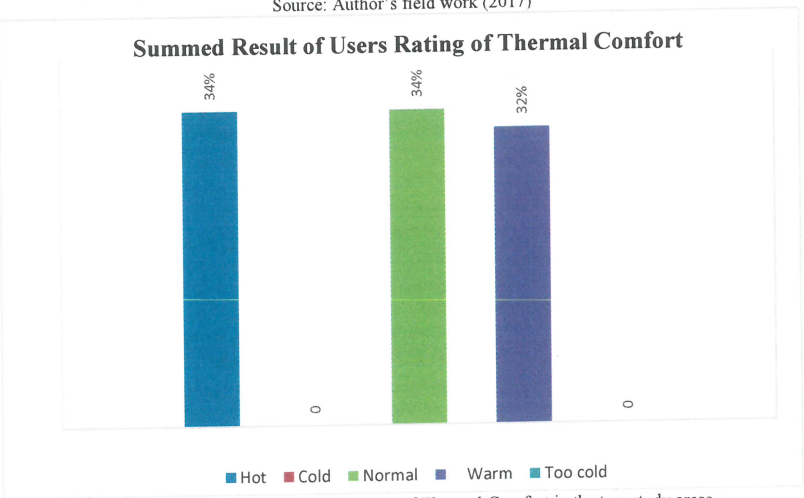

Figure 2: Summed Result of Users Rating of Thermal Comfort in the two study areas.
Source: Author's field work (2017)

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