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Assessing The Element Integration of Passive Design Strategies: A Mixed-Method Evaluation of Thermal Comfort and Spatial Flexibility in Architecture Faculties

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Abstract- In hot, humid climates, designing a building to stay cool and comfortable without relying heavily on energy-guzzling systems isn't just a nice-to-have it's essential. Orientation, ventilation, shade, thermal mass, and daylighting among others will certainly help. Here comes the tricky part though; employing one or two of the techniques will not necessarily guarantee good performance of the building. What counts at the end of the day is how they come together. This study looked at exactly that how well passive design elements are integrated in six architecture schools around the world, with the goal of applying those lessons to architecture faculties in Nigeria. The researchers used a mix of observation and case study analysis. The six schools chosen were: Fay Jones (USA), KTH (Sweden), Abedian (Australia), Rwanda, Rivers State University (Nigeria), and Özyeğin University (Turkey). The team observed things like microclimate, building materials, flexibility, and functionality. The results? Only two of the six schools scored high on integration (18 out of 22 or above). The Nigerian case study scored the lowest just 10 out of 22. What was missing? Movable shading, cross-ventilation pathways, and retractable elements that let spaces adapt throughout the day. So what does this mean for Nigeria architecture faculties? The study also summarizes some practical design strategies, such as using hexagonally-shaped floor plan layouts, reflective roof coverings, movable windows on the north and south sides, and even sensors for automation purposes.

Index Terms- Passive Design Strategies, Element Integration, Thermal Comfort, Faculty of Architecture.

I. INTRODUCTION

Thermal comfort refers to the "state of mind that expresses satisfaction with the surrounding thermal environment and can be assessed through subjective evaluations" (ASHRAE 55, 2020). Thermal balance of the body involves several parameters, including the temperature of the air, radiant temperature, air speed, and humidity (Olesen & Parsons, 2002). The metabolic rate, clothes worn, and gender can be other physiological factors affecting thermal comfort (ASHRAE 55, 2020). Higher indoor temperatures like 30°C will have adverse effects on mental functioning and concentration for students (Wargocki & Wyon, 2017). Construction of the building should not just be limited to construction, but safety and thermal comfort as well.

The NUC and ARCON standards set performance benchmarks in terms of space and thermal issues in architectural schools. The Core Curriculum Minimum Academic Standards (CCMAS) (NUC, 2022) offer information regarding studios, classrooms, laboratories, and offices. Still, many faculties do not meet these standards and often have issues like poor air quality, insufficient ventilation, limited daylight, and rigid studio spaces. Although passive design is becoming more recognized, architecture faculties in Nigeria's hot-humid regions continue to face thermal discomfort and depend on HVAC systems. Without a formal way to assess passive design features, it is difficult to spot problems or replicate successes. This research examines how passive design features are used in architecture faculties in Nigeria. This study explores space requirements on the basis of the NUC (2022) CCMAS criteria, identifies passive design characteristics in six existing architecture faculties, studies thermal comfort within the education environment, and creates design guidelines for flexible spaces by using passive design concepts. The research questions to be used as the foundation for this research paper are as follows: What are the passive design aspects that are not present in the chosen faculty buildings? What role does the environment play with regard to thermal comfort in the studios? What are the materials used to create passive cooling structures in tropical environments?

What role do the use of portable devices play in facilitating passive design? This paper analyzes passive design in six architecture departments chosen for investigation. This is essential since Nigerian studios experience low thermal comfort, passive design standards must be met, and new architecture faculties in Nigeria provide a good opportunity for improvement.

II. LITERATURE REVIEW

2.1 Passive Design Strategies in Architecture

Passive design concept creates comfort conditions in living areas by doing away with the requirement of artificially heating or cooling the environment using the Passivhaus concept created in Germany in 1991. Technology employs natural elements such as sunlight, wind, and natural materials to control temperatures. In Nigeria, the main passive design technologies are shading, building alignment, ventilation, insulation, and reflective materials. Studies have shown that these techniques help minimize heat and humidity, but when combined with roof insulation and reflective materials, they provide even greater efficiency (Xu et al., 2025).

2.2 Criteria for Passive Design and Building Form

The standards that apply to thermal comfort are ASHRAE 55 (2020) and ISO 7730 (2005), considering metabolic rates, insulating clothing, air temperatures, radiant temperatures, air velocities, and humidity. In terms of the architectural design, science has proven that the use of hexagon shapes within openings in the façade is effective in helping with ventilation because of the multiple routes that help reduce cooling loads. In addition to that, retractable furniture forms part of the passive design due to its ability to be retracted and provide multiple uses (Hussey Seatway, 2025). Another method used for flexible space and acoustic adjustment is the wall retraction system (Figueras Seating, 2024).

2.3 Materials Used for Passive Cooling in Tropical Regions

Technological improvements for passive cooling systems can be made through the use of green roofs to shade and cool the roof, and the use of courtyard pools to cool the interiors due to their evaporative cooling effect (Xu et al., 2025). The tintable large-scale electromagnetic window with gray tinting technology is more effective than the blue-tintable electrochromic windows. Reflective roofing is very efficient; a field study conducted in Kaduna, Nigeria, showed that a combination of polystyrene insulation and reflective coating on the roof significantly reduces interior temperatures during the hottest hours of the day (Xu et al., 2025).

2.4 Factors Affecting Thermal Comfort

From ASHRAE 55 (2020) and Olesen & Parsons (2002), the main parameters that influence thermal comfort are air temperature, radiant temperature, air velocity, and relative humidity. Temperatures exceeding 30°C hinder cognitive function (Wargocki & Wyon, 2017). The PMV index formulated by Fanger (1970) determines thermal sensations through metabolic rate and insulation level of clothing combined with the four parameters mentioned. Air velocity creates a physiological cooling effect through convective heat exchange. Humidity levels between 40%-70% will have no considerable impact on thermal comfort, whereas high humidity decreases the effectiveness of sweating, which is the key strategy for the human body to lose heat (ASHRAE 55, 2020). Personal characteristics such as metabolic rate, level of clothing insulation, gender, and body size influence thermal comfort (ISO 7730, 2005). Olgvay (1963) first outlined the thermal comfort zone in architectural terms, defining conditions where the average person feels comfortable.

2.5 Space Requirements and Theoretical Framework

According to NUC (2022), minimum space requirements for architecture faculties include: 2.5 sqm per student for studios (four studios for 40 students each); 0.5 sqm per student for classrooms; 0.9 sqm per student for laboratories/workshops; 12 sqm per staff office; and 2 sqm per student for libraries. Three theories inform this study. Theory of Multi-Functional Furniture allows easy modification of learning spaces, with historical precedents from ancient Egypt and China. Natural ventilation principles were advanced by Hassan Fathy (1969), who promoted architecture based on wind capture and stack effect (chimney) ventilation in traditional Egyptian settlements. Sensor-Based Automation Theory is characterized by sensor usage to measure surroundings, enabling automated building systems

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for energy efficiency and occupant comfort (Oyeleye et al., 2025).

III. METHODOLOGY

The research involved mixed methods of research. Quantitative and qualitative research and case study methods were utilized. Case studies were selected on the basis of their uniqueness, functionality, climatic conditions, geographical spread, and data verification. Data gathering was done through the use of three tools, which include a checklist used for collecting information on the micro-climate variables (solar radiation, temperature, ventilation), building materials, flexibility, and function; observation through physical examination of Rivers State University alongside reading of case studies internationally, and secondary data that included NUC (2022) guidelines, peer-reviewed journals, and project reports. Independent variables considered in the study include air temperature, radiant temperature, air movement, and relative humidity, while dependent variables include metabolic rate, clothing insulation, gender, and body composition. The incorporation of passive design was evaluated against eleven parameters based on ASHRAE 55 (2020) and ISO 7730 (2005) standards using a scoring of 0 to 2 (0 = absence, 1 = partial presence, and 2 = full presence).

S/N	Case Study Name	Location	Climate Context
1	Fay Jones School of Architecture	USA	Temperate
2	School of Architecture at KTH	Stockholm, Sweden	Cold
3	Abedian School of Architecture	Queensland, Australia	Subtropical
4	Faculty of Architecture and Environmental Design	Kigali, Rwanda	Tropical highland
5	Faculty of Environmental Science	Rivers State University, Nigeria	Hot-humid
6	Faculty of Architecture and Design, Özyeğin University	Istanbul, Turkey	Mediterranean

IV. RESULTS AND DISCUSSION

4.1 Overview of Case Study Findings

The observation schedule was applied to all six case studies.

Table 1: Composite Passive Design Integration Scores

Case Study	Composite Score (0–22)	Integration Level
Fay Jones School of Architecture (USA)	18	High
School of Architecture at KTH (Sweden)	19	High
Abedian School of Architecture (Australia)	16	Moderate-High
Faculty of Architecture (Rwanda)	14	Moderate
Faculty of Environmental Science (Rivers State, Nigeria)	10	Low
Özyeğin University (Turkey)	15	Moderate

4.2 Detailed Results by Criterion

Table 2: Criterion Scores per Case Study (0–2 scale)

Criterion	Fay Jones	KTH	Abedian	Rwanda	Rivers State	Özyeğin
Climate responsiveness	2	2	2	1	1	2
Site conditions	2	2	2	1	1	1
Orientation	2	2	1	1	1	2

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Building form/layout	1	2	2	1	0	1
Natural ventilation	2	2	2	2	1	2
Solar control	2	2	1	1	1	2
Daylighting	2	2	2	2	1	2
Materials	2	2	1	1	1	1
Thermal comfort	1	1	1	1	1	1
Energy efficiency	1	1	1	1	1	1
Cultural suitability	1	1	1	1	1	1
TOTAL	18	19	16	14	10	15

4.3 Microclimate Analysis

Table 3: Microclimate Strategies per Case Study

Case Study	Solar Radiation Control	Temperature Management	Ventilation Strategy
Fay Jones	Double-skin glazing with fritted glass fins	Gas/liquid circulation in glazing	Well-ventilated spaces
KTH	Documented in plans	Thermal mass strategies	Cross-ventilation
Abedian	Shading devices	Passive cooling	Natural ventilation
Rwanda	Smaller openings N/S	Extensive glazing	Hot air outflow/cool air inflow
Rivers State	Recessed large windows	Vegetation + large windows	Large window airflow
Özyeğin	Smaller openings N/S	Extensive glazing	Hot air outflow/cool air inflow

4.3 Building Materials Analysis

Table 4: Materials Used per Case Study

Case Study	Primary Materials
Fay Jones	Tensioned concrete, zinc panel cladding, glass, fritted glass, ceramic tiles, wood
KTH	Steel, concrete, glass
Abedian	Steel, concrete, glass
Rwanda	Steel, reinforced concrete, glass
Rivers State	Steel, reinforced concrete, glass
Özyeğin	Steel, reinforced concrete, glass, wood panels

4.5 Spatial Flexibility Analysis

From the supplementary document survey of 22 architecture faculties, the availability of flexible spaces was assessed:

Table 5: Availability of Key Flexible Spaces

Facility	Fay Jones	KTH	Abedian	Rwanda	Rivers State	Özyeğin
Reception	YES	YES	YES	YES	YES	YES
Administrative area	YES	YES	YES	YES	YES	YES
Drawing Studio	YES	YES	YES	YES	YES	YES
Academic Classrooms	YES	YES	YES	YES	YES	YES
Seminar Room	YES	YES	YES	YES	NO	YES
Jury/Exhibition Space	YES	YES	YES	YES	YES	YES

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Modelling Room	YES	YES	YES	YES	YES	YES
Retractable Seating	NO	NO	NO	NO	NO	NO
Retractable Walls	NO	NO	NO	NO	NO	NO

Key Finding: Among the six different case studies that have been analyzed for this study, there is not a single one that includes retractable seats, walls, and tables. The importance of these elements in the creation of flexible space and passive ventilation has been accepted (Hussey Seatway, 2025; Figueras Seating, 2024).

4.6 NUC Space Requirements Compliance

Based on the NUC (2022) CCMAS standards, the Rivers State University case study (the only Nigerian faculty physically assessed) showed the following compliance gaps:

Space Type	NUC Requirement	Observed Status	Compliance
Studios (4 studios)	2.5 sqm/student	Insufficient studios	Partial
Classrooms	0.5 sqm/student	Adequate	Yes
Jury/Exhibition Space	Required	Present but inadequate	Partial
Staff offices	12 sqm/staff	Adequate	Yes
Seminar Room	Required	NOT PRESENT	No

4.7 Discussion

4.7.1 Integration of Passive Design: Findings and Gaps

The results reveal a clear hierarchy of passive design integration across the six case studies. The highest-performing cases KTH (Sweden) and Fay Jones (USA) achieved scores of 19 and 18 out of 22, respectively, sharing characteristics of synergistic multi-strategy integration and climates prioritizing passive heating. Moderate performers included Abedian (Australia, 16), Özyeğin (Turkey, 15), and Rwanda (14). These exhibited excellent individual strategies; however, they failed to integrate the designs fully. The lowest-performing institution was Rivers State University in Nigeria, scoring 10/22. This agrees with the findings of Xu et al. (2025) that passive cooling techniques are often not sufficiently integrated during the design of buildings in Nigeria, leading to high dependency on air-conditioning. Deficiencies identified in Rivers State University included the absence of a seminar room as per NUC guidelines, fixed spatial configurations, use of large windows without retractable blinds/shutters, and lack of cross-ventilation zones. It is also important to note that none of the case studies used retractable walls or seating arrangements despite existing product solutions (Hussey Seatway, 2025; Figueras Seating, 2024). Regarding materials, all six cases used traditional materials such as steel, concrete, and glass. Only Fay Jones resorted to high-technology materials such as fritted glass; however, none of the cases adopted green roofs or courtyard ponds suggested by Xu et al. (2025). The findings also align with the natural ventilation principles documented by Fathy (1969) in traditional Egyptian architecture.

4.7.2 Implications, Limitations, and Future Directions

From the findings of the study, seven design strategies can be implemented for architecture faculties in Nigeria: hexagonal-shaped building forms for enhanced airflow control (Aeinfar & Serteser, forthcoming); reflective roofs using polystyrene insulation and reflective paints to help lower indoor peak temperatures (Xu et al., 2025); north/south facing cross-ventilation windows; mobile spatial components that include folding tables, dividers, and seating arrangements to facilitate changes in airflow; automatic systems using sensors to monitor temperature and humidity levels (Oyeleye et al., 2025, attained 83.3% energy conservation); plant holders used to help cut down pollution and improve air quality; and jury/exhibition halls which are required by NUC (2022). Some limitations of this study are the lack of seasonal observations over one year; radiant temperature being assumed rather than measured; and the use of literature to study international cases rather than on-site visits. There is need to conduct 12-month monitoring of indoor environmental quality in Nigerian architecture faculties; design and test a prototype studio building with folding walls and sensor-based automation; compare hexagonal with rectangular building plans; and create a passive design integration tool for Nigerian universities.

V. CONCLUSION

The study analyzed the inclusion of passive design principles in six architecture departments based on their climatic conditions. Using mixed-methods case study analysis, it was found that among the six cases reviewed, Fay Jones and KTH were the two with the highest integration scores (≥18/22), while Rivers State University scored the lowest (10/22). Missing elements across the six case studies included movable shading devices, retractable walls/seating, and sensor-based automation.

These results affirm that passive design integration should not just involve the addition of components but rather the coordinated integration of orientation, envelope, material, and movable parts. The present study provides a replicable framework for assessment and gives design suggestions for architecture faculties in Nigeria, which include hexagonal arrangement, reflective roof material, operable windows on north and south walls, flexible spaces, and sensor-controlled automation.

This research makes an important contribution to the literature on passive design in tropical educational facilities by providing guidelines to designers, policymakers, and university authorities on how to create sustainable and energy-efficient architecture faculties.

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