Investigating Architecture Students' use of Passive Design Strategies in Covenant University, Ota, Ogun State, Nigeria.

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Abstract

One of the most contemporary discourses in architectural practice and research is passive design, particularly with the current reality of climate change. This is because it can be used to promote thermal comfort and energy efficiency in buildings. However, there is little or no studies on the extent of using these strategies by the architecture students' in their designs. Therefore, this research aims to assess the use of passive design strategies by students of architecture department in Covenant University. Covenant University was chosen as a case study in this study because it is one of the best schools of architecture in Nigeria. It and accredited by the Nigerian Institute of Architects and the Architects Registration Council of Nigeria. The research was carried out by administering close-ended questionnaires to the architecture student (200level –Msc2). Using the Yemane formula, the sample size obtained was 150. The survey carried out between March and April 2019. The results were presented using descriptive statistics, and the 5-point Likert Scale was used as a means of measurement. The key finding revealed that most students have knowledge of passive design and also incorporate it into their design studio. Majority of the architecture students came across passive design and its strategies through personal studies. The top three major factors that influence the students' use of passive design strategies are; design brief, Level of knowledge, and site constraints. The study ends with the following recommendation that seminars should be organized for students and lecturers to improve the adoption of passive designs by Student Architect.

Keywords: passive design, thermal comfort, energy efficiency, Architects, Lagos state
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1.0 Introduction

Passive design is a prevalent issue for good quality buildings, particularly nowadays, with the recent global warming reality, climate change, and economic recession **(Akhimien&Latif, 2019)**. Passive design refers to the use of external variables like climate, sun path, trade winds and temperature to maintain a sustainable inward temperature in the design procedure. It is a design that exploits the external factors in an environment to maintain a comfortable temperature in a building and hence, improving the wellbeing and comfortability of people residing in houses prone to harsh climates **(Akinola et al., 2020; Ameur et al., 2020)**. It precedes active strategy **(Sahida*et al*., 2020)**. Moreover, a combination and active and passive design strategies are highly desired to achieve sustainability in housing and architectural designs **(Inusa&Alibaba, 2017; Shi *et al*., 2020)**. As indicated by **Tablada*et al*. (2005)**, cooling effects in structures can be relieved by a major procedure called passive design. **Akande (2010)** attested that passive design decreases or takes out the requirement for supplementary heating or cooling. In addition, **Edwards *et al*. (2006)** stated that passive design is not a connection or supplement to architectural design, but a design process that incorporates with building structure. **Adedayo*et al.* (2013)** pointed out that thermal comfort issues should be handled at the architectural design stage, especially in Nigeria's warm moist atmosphere. Asides the fact that passive designs can be applied primarily to new structures; it has also been used for renovations.

The global community is steadily gaining towards sustainability, and passive design helps achieve a certain level of sustainability in design. The Architect's principal role is to design visual and thermal comfort buildings for occupants **(BtMohdNawayai*et al*., 2020)**. Hence, student architects should implement these passive design strategies in their design studio to design sustainable buildings. Passive design strategies used by architects in practice are currently established in the literature **(Tablada*et al*., 2005; Akande, 2010)**. For instance, in Nigeria, **Akande (2010)** researched the passive design strategies for built-up areas in dry and hot climates. The investigation showed that using some passive design strategies like right selection materials in building, proper orientation of building, and adequate natural ventilation can decrease the energy consumption for cooling in the structures and provide natural cooling. In another study, **Ibem*et al*. (2019)** revealed that Architects based in Lagos state have good knowledge about passive design strategies in the research carried out on architects' awareness of passive design strategies in buildings used as terminals that are located in Lagos state. The study identified strategies like daylighting, building orientation, suitable landscaping and natural ventilation as the major strategy used for the passive design of buildings used as terminals. In Lagos State, Nigeria, **Akinola*et al*. (2018)** also identified some passive design strategies in investigating the adoption and awareness of Architects on building envelope technologies for energy-efficient housing. The study identified passive design strategies like window attachments, external overhangs, and double-gazed windows as building envelope technologies for low-energy housing units.

However, the use of these strategies by students in training has been inadequate. Furthermore, there are scarce studies on the extent of usage of these strategies by the architecture students in their designs. This study aims to investigate architecture students' use of passive design strategies with a view to improving the education curriculum of schools of architecture. The study's objective includes: (i) To identify the passive design strategies used by the architecture students in the study area. (ii)To examine the extent of usage of the passive design strategies by architecture students in the study area. (iii)To explore the factors that influence the use of passive design strategies. The outcomes of this investigation are likely to enhance architectural education policy and practice in Nigeria. The study also contributes to the current body of knowledge on passive design strategies form the student's perspective.

2.0 Literature Review

Historically, passive design strategies have influenced buildings in past generations. The concept has featured in contemporary architectural discourse (**Ogunyemi*et al*., 2015; Han & Liu, 2020),** for example, in the context of vernacular architecture **(Zhong*et al.*, 2019)**. As earlier mentioned, one of the least expensive and operational strategies for sustainable building design is passive design. Also, **Brown (2011)** opined that a decent passive design guarantees that the occupants or clients maintain thermal well-being with little or no assistance in cooling and heating depending on the climate where the buildings are located.

Several passive design strategies have been identified in the Literature. For example, **Rodriguez-Ubinasa*et al*. (2014)** identified passive design strategies like orientation of the building on the site, layout of building, design of window, adequate ventilation insulation and thermal mass of building materials as well as shading devices. **Thomas and Garnham (2007)** emphasized that building orientation is a crucial strategy to consider first while designing passive buildings. According to **McGee (2013)**, building orientation is how you locate your structure on the site to exploit climate conditions, such as cooling wind and sunlight. For instance, in climates with hot temperatures and high rainfall, living zones would preferably look towards the south, or as near south, as could reasonably be expected, enabling minimum sun exposure and reduces the requirement for supplementary cooling and dynamic cooling gadgets. The structure will be increasingly comfortable to reside in and less expensive to run. In addition to proper orientation, buildings should avoid large openings on the west and east, which accept more sunlight when likened to the south and north sides. Succinctly put, proper orientation of building assesses favorable sunlight and cool breeze.

There is a direct link between sun shading devices and sun path. For countries with hot temperatures and high rainfall**, Koch-Nielsen, (2007)** recommends the projected canopy at the topmost point of windows on the west and east as well as bulging fins at the sides of windows on the north and south as the most appropriate shading device. This was probably why **McGee (2013)** opined that the viable shading possesses the ability to hinder up to 90% of the sun's heat. It should also be noted that viable shading can incorporate window canopies, awning, roof, shutters, screens, pergolas, and plantings. Also, exposed glass is commonly the paramount avenue of heat absorption into a building. Therefore, it is imperative to reduce undesirable heat absorption into the building. By computing the sun's angles for your setting and considering climatic conditions and orientation of the building, you can make use shading to enhance the thermal comfort.

The usage of materials with relatively above-average thermal mass all through any structure can save fundamentally on bills for cooling. However, the use of the thermal mass must be done correctly. Poor utilization of thermal mass can fuel the extremes conditions, emanating heat amid hot or dry seasons, causing a great deal of undesirable heat gain and user discomfort and uneasiness. Decent utilization of thermal mass moderates interior areas' temperature by averaging temperature of day-night boundaries **(Shaviv *et al*., 2001; Lechner, 2009)**. A recent study showed that solar reflectance, which is one of the least utilized passive strategies, reduces indoor temperature, especially during the summer period in hot climates **(Fernandez-Antolin*et al*., 2019)**.

A look at some selected existing studies showed that passive strategies have helped to mitigate the harsh effects of climate change in terms of achieving thermal comfort and optimization of energy consumption especially in coastal areas where according to **Nematchoua*et al*. (2020)** are very vulnerable to the devastating effects of the climate change. Apart from climate change, passive design strategies can reduce the incidence of environmental pollution **(Abass*et al*., 2020)**.

McGee (2013) stated that windows and doors could account for more heat gain or loss than some other component in an insulated structure envelope. Also, choosing the right size and area of window openings in the building can be used to subdue issues related to thermal performance

Boubekri*et al*. (1991) explained the concept of operable windows. **Konya (1980)** stated that window openings in the hot climate should be big to catch breeze from the prevailing wind. Operable windows are regular components found in passive designs. They are essentially windows that can be opened. Also**, McGee (2013)** attested that skylights could impact on comfort and energy effectiveness. It should also be noted that skylights admit more light when compared to a vertical window of a similar size. spacing (to regulate heat absorption and glare), effectiveness of energy, sizing, and appropriate climatic conditions should be considered when selecting a skylight.

Keftin and Yerima(2016) described courtyard as semi-outdoor space opened to the heavens within a building. **Buluset *al*. (2017)** emphasized the significance of the courtyard microclimate to the building structure. Courtyards would improve the ventilation and daylighting of the building.

Form the above mentioned; it can be pointed out that to accomplish a green or sustainability in buildings, architects can consider taking advantage of passive design strategies such as proper orientation of building, sun shading devices, courtyards as well as operable windows, which have been proven to significantly influence thermal comfort and energy efficiency in many studies. Also, there are numerous passive design strategies in Literature. However, only the selected strategies discussed in this study can apply to the hot Nigeria climate **(Ochedi*et al*., 2016; Alagbe*et al*., 2019)**.

3.0 Methodology

The study population consists of the students of undergraduates and postgraduates, except for the 100level students is 224.

Table 1: Study Population distribution across all levels

Undergraduate	200 Level	300 Level	400 Level	Population
	61	52	52	165
Postgraduate	MSc 1	MSc 2		
	37	22		59
Total population				224

The sample size was determined using the formula from **Quora (2019)**:

$$n = z2pqN/\ e2\ (N-1) + (z2pq)$$

Where; n = sample size, P =level of confidence (for 95 percent confidence level, p = 0.05), q= 1 – p (sample proportion), N = population size, z = the standard normal deviate (or confidence coefficients), which corresponds to the confidence level adopted. (z= 1.96 for 95% confidence), e = acceptable error (0.02 for 2% of true value). Using this formula, a sample size of 150 was gotten. Research data obtained through the various data collection methods was analyzed based on the feedback gotten from the questionnaires distributed.

The questionnaire was administered between March and April 2019. Questionnaires were used to obtain the data. The questionnaires were collected, coded, and analysed. The data were analysed using simple descriptive statistics. The sum of the weighted values (SWV) over the total value was obtained for each variable. Subsequently, ranking was done based on the index. Variables that are ranked from first to last in decreasing order of the weight based on the Likert scale coding. Factors that are ranked first are of top importance, while those ranked last are of least importance. The results are presented using tables and charts Q = EFx/N Where, Q = Mean, Σ = Summation, Fx = Frequency of x and N=Number of occurrences. To obtain the perception aggregate index (I) of each service, a weight value of 5,4,3,2 and 1 was assigned to the 5-point Likert scale ratings.

The summation of weight value (SWV) for each variable was obtained from the addition of each rating's product of weight value and the number of responses of each rating. The perception aggregate index (I) for each variable was obtained from the division of each summation of value (SWV) by the total number of respondents, which is represented as "N." Index(I) = SWV/N. The use of frequency charts and graphs were applied to analyze the data properly. For this process, the Statistical Package for the Social Sciences (SPSS) will be used. This software would help in the analysis and conversion of raw data into a statistic presentation. From the results obtained, we were able to determine the frequency of the use of passive designs.

4.0 Results and Discussion

The architecture students in Covenant University filled the 150 questionnaires administered to them. Thirty-seven questionnaires were administered to 200 level students, 34 questionnaires were administered to 300 and 400 level students, 22 questionnaires were distributed to the M.Sc. 1 students, and 23 questionnaires were administered to the M.Sc. 2 students. A total of 150 questionnaires were gotten back after collection.

4.1 Extent of Knowledge on Passive Design

The extent of knowledge on passive design by the respondents is presented in **Table 2**.

Table 2: The frequency and percentage of the extent of knowledge of the respondents.

	Frequency	Percent
not knowledgeable at all	2	1.3
not knowledgeable	10	6.7
not sure	23	15.3
knowledgeable	83	55.3
highly knowledgeable	32	21.3
highly knowledgeable	32	21.3
Total	150	100

From **Table 2**, 21.3% of the respondents are highly knowledgeable about passive designs, 55.3% of the respondents are knowledgeable about passive designs, 15.3% of the respondents are not sure, 6.7% of the respondents are not knowledgeable, and 1.3% of the respondents are not knowledgeable at all about passive design. This finding shows that a significant percentage of the students are knowledgeable about passive designs. This is in line with the results of **Ibem *et al.* (2019)** that revealed that the architects are also knowledgeable about passive design strategies as used in terminal buildings. This is probably because there has been increasing interest among architects and other built environment professionals in achieving energy-efficient buildings.

4.2 Application of passive design strategies in design studio of the respondents

The perceived usage of passive design strategies in design studio by the respondents is presented in **Table 3**.

Table 3: The percentage and frequency distribution of the usage of passive design strategies of the respondents in their design studio

	Frequency	Percent
never	3	2.0
rarely	8	5.3
sometimes	30	20.0
often	47	31.3
always	62	41.3
Total	150	100

From **Table 3**, 41.3% of the respondents always incorporate the strategies of passive design in their design studio, 31.3% of the respondents often incorporate the strategies in their design studio, 5.3% of the respondents rarely incorporate the strategies of passive design in their studio, and 2% of the respondents do not apply the passive design strategies in their studio design. The findings suggest that most of the respondents use passive design strategies in their design studio.

4.3 Perceived level of satisfaction of knowledge of passive design

Perceived level of satisfaction of knowledge of passive design as responded is presented in **Table 4**.

Table 4: The percentage and frequency distribution of the level of satisfaction of knowledge on passive design by the respondents

	Frequency	Percent
extremely unsatisfied	7	4.7
unsatisfied	27	18.0
undecided	35	23.3
satisfied	71	47.3
extremely satisfied	10	6.7
Total	150	100

From **Table 4**, 6.7% of the respondents are extremely satisfied with their knowledge on passive designs, 47.3% of the respondents are satisfied with their knowledge on passive designs, 23.3% of the respondents were undecided, 18% of the respondents were unsatisfied and 4.7% of the respondents were extremely unsatisfied. The findings suggest that major percentage of the respondents were contented with their knowledge on passive designs.

4.4 Source of information on the passive design strategies

The respondents' source of information on the passive design strategies is presented in **Table 5**.

Table 5: the percentage and frequency distribution of how the respondents came across the strategies of passive design.

	Frequency	Percent
school	13	8.7
practice	10	6.7
seminars	12	8

personal study	48	32
lectures	23	15.3
others	44	29.3
others	44	29.3
Total	150	100

From **Table 5**, 32% of the respondents acquired their knowledge of passive design from personal studies, 8.7% of the respondents acquired their knowledge of passive design from school, 6.7% of the respondents acquired their knowledge of passive design from practice, 8% of the respondents derived their knowledge of passive design from seminars, 15.3% of the respondents acquired their knowledge from lectures and 29.3% of the respondents obtained their knowledge from other sources. The outcome of this study shows that majority of the respondents acquired their knowledge of passive design through personal studies.

4.5 Level of awareness on passive design strategies

The respondents' perceived level of awareness on passive design strategies is presented in **Table 6**.

Table 6: Level of awareness of each passive design strategies

PDS	HU	U	UD	A	HA	Total	SWV	Adverse index	Rank
A	0	4	21	44	81	150	652	4.3	1
B	1	6	16	54	73	150	632	4.2	2
C	2	9	17	61	61	150	620	4.1	3
D	6	12	18	48	66	150	606	4	4
E	2	9	28	70	41	150	598	4	4
F	3	14	22	59	52	150	593	4	4
G	3	13	26	65	43	150	582	3.9	7
H	11	26	30	52	31	150	516	3.4	8

A = Cross-ventilation; B = Courtyards; C = Operable windows; D = Shading devices (eaves, awnings, overhangs, pergolas, shutters); E = Building orientation; F = Layouts and zoning; G = Skylights; H = Thermal mass (heat absorbing materials). HU = Highly unaware; U = Unaware; UD = Undecided; A = Aware; HA = Highly aware. PDS = Passive design strategies.

From **Table 6**, the three most common strategies among the respondents were cross-ventilation, courtyard systems, and operable windows, and the three least common strategies among the respondents are layouts and zoning, skylights, and thermal mass. Other strategies that were somewhat known are the use of shading devices and building orientation. Therefore, it can be deduced that the respondents are mostly aware of the top three strategies. It is also deducted that most of the respondents were conversant with cross ventilation as a strategy for passive designs but not thermal mass. This is probably because one of the relevant issues in building science in recent times is the application of natural ventilation, which can be achieved by the use of cross ventilation and courtyards.

4.6 Extent of application of passive design strategies

The respondents; perceived measure of the extent of application of passive design strategies is presented in **Table** 7.

Table 7: the extent of application of the knowledge of passive design in design studio of the respondents

	Frequency	Percent
not at all	1	0.7

to a little extent	7	4.7
undecided	10	6.7
to some extent	65	43.3
to a large extent	66	44
Total	150	100

From **Table 7**, 44% of the respondents apply the knowledge of passive design to a large extent in their design studio, and 0.7% of the respondents do not apply the knowledge of passive design in their design studio at all. Therefore, it is deduced that majority of the respondents apply the knowledge of passive design that they have in their design studio.

4.7 Level of usage of the following passive design strategies

The extent of usage of the passive design strategies is presented in **Table 8**.

Table 8:Level of usage of passive design strategies

	N	R	S	O	A	Total	SWV	Adverse index	Rank
A	1	4	23	63	59	150	625	4.2	1
B	2	11	30	43	64	150	606	4	2
C	3	10	34	57	46	150	583	3.9	3
D	3	24	31	29	63	150	575	3.8	4
E	5	10	34	65	36	150	567	3.8	4
F	6	24	27	58	34	149	537	3.6	6
G	5	16	52	45	31	149	528	3.5	7
H	20	29	25	49	27	150	484	3.2	8

A = Cross-ventilation; B = Courtyards; C = Operable windows; D = Building orientation; E = Shading devices (eaves, awnings, overhangs, pergolas, shutters); F = Layouts and zoning; G = Skylights; H = Thermal mass (heat absorbing materials). N = Never; R = Rarely; S = Sometimes; O = Often; A = Always.

From **Table 8**, the 3 most common strategies used or applied among the respondents were cross-ventilation, courtyard systems, and operable windows, and the three least common strategies used among the respondents are layouts and zoning, skylights and thermal mass. Other strategies that are sometimes used are shading devices and building orientation. This shows that the respondents mostly make use of the top 3 strategies, and it is deduced that the majority of the respondents make use of cross ventilation as a strategy for passive designs but not thermal mass. It was also observed that when compared with **Table 6**, the degree to which these passive design strategies are known relates to the extent it is being used. This finding was in agreement with **Akande (2010)** that pointed out that passive design strategies can be adopted in this climatic region to minimize energy use for cooling, improve occupant's comfort, and enhance low energy architecture**.**

Table 9: Extent to which the following factors influence the use of passive design strategies

	NT	AL	UD	TS	TA	Total	SWV	Adverse index	Rank
A	0	6	9	44	88	147	655	4.5	1
B	1	12	16	45	76	150	633	4.2	2

C	0	5	19	70	55	149	622	4.2	2
D	0	12	27	52	58	149	603	4	4
E	1	11	28	73	37	150	584	3.9	5
F	1	12	35	60	42	150	580	3.9	5
G	11	15	33	43	48	150	552	3.7	7
H	4	18	32	64	32	150	552	3.5	8
I	9	14	42	53	31	149	530	3.5	8
J	12	21	35	41	40	149	523	3.5	8

A = Level of knowledge; B = Design briefs; C = Site constraints; D = Lack of technical know-how; E = Time frame given for the project; F = Development control standards; G = Concerns about durability; H = Lecturers preference; I = Concerns about privacy; J = Concerns about security. NT = Not all at; AL = A little extent; UD = Undecided; TS = To some extent; TA = To a large extent.

From **Table 9**, the three top factors that influence the use of these passive design strategies are level of knowledge on passive design, design briefs, and site constraint due to analysis of the site. The three least factors influencing the use of passive design strategies are the lecturers' preference, privacy, and security concerns. Some other factors that can also influence the use of passive design are technical know-how, time frame given for the project, and development control standards. The level of knowledge will come a long way in influencing the use of passive design because you cannot apply what you do not know. Therefore, it is deduced that the level of knowledge influences the adoption of passive design strategies by the majority of the respondents.

Conclusion

As earlier mentioned, one of the least expensive and effective strategies for sustainable building design is passive design, of which some experts are believed that they are old **(Lotfabadi&Hançer, 2019)**. In schools of architecture, these passive design strategies need to be implemented in their architectural courses because the world is steadily moving into the realm of sustainability, where the need to take care of our environment has increased. Therefore, this study ends with the following recommendations:

(i). Passive design should be stressed more in schools of architecture by adding it to the course curriculum required in architecture

(ii). Passive design strategies can also be used as one of the requirements by students' mentors when giving briefs in the design studio. This will challenge the students to learn more about the strategies of passive designs.

(iii). Students should endeavor to attend seminars and go for conferences to learn about passive design and its associated strategies.

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