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Transposing Architectural Technology Curriculum in Nigerian Polytechnics for Sustainable Built Environment

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Abstract. *Architectural technology programme in Nigeria has steadily affected the trajectory of indigenous identity and environmental awareness to contextual issues peculiar to the Nigerian milieu. As the world grapples with the aftermath of COVID-19 and the ensuing new normal characterised by a preponderance of remote activities, attention is drawn to the design and utility of spaces. This study examined the academic curriculum contents of professional courses offered in architectural technology programmes in Nigerian polytechnics to ascertain inherent factors that enable implementation of design principles for sustainable built environment. This is imperative since the products of this programme constitute key players in the execution of sustainable, safe and inclusive human settlements and cities. This study is based on survey type of research design; three institutions were selected following a stratified random process and two sets of structured interviews administered to two groups of respondents comprising the Higher National Diploma (HND) graduating class and the teaching staff. The data collected were analysed using percentile, mean scores and regression analysis. The findings revealed a significant awareness and implementation of principles of sustainable design especially at inception stage by the HND students. However, the students' proficiency with varied CADD software packages was limited. The paper concludes that addressing the shortfalls of the academic curriculum will promote high quality learning in the programme required to ensure the creation of sustainable built environments.*

Keywords *Architectural Technology, Curriculum, Sustainable, Built environment, Lifelong learning*

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I. Introduction

The global warming and ensuing campaign for individual action ascribed by the United Nation's 'ActNow' campaign, propels everyone to actively participate in the collective effort to curb global warming (United Nations, 2019). Three major principles of sustainable design are identified in the context of architecture; Economy of resources, Life cycle design and Humane Design, with the main goal to discover architectural solutions that ensure seamless equilibrium between built and natural environments (Kim & Rigdon, 1998). Sustainable design is a combination of procedures that ensures that the built environment attains exceptional levels of ecological stability through innovative and retrofit construction techniques that ultimately aims for enduring viability and humanisation of architecture (Loftness, 2013). Awareness and relevance accorded novel suggestions that influence sustainable built environment are key factors in the implementation of sustainable design principles. At the learning stages these factors should be reflected at the outset of design processes. This infers that education plays a primary role and ensuring that students know and make the right design decisions during the learning stages is paramount. This paper is an exploration of the academic curriculum contents of architectural technology programmes in Nigerian polytechnics to determine to what degree students in the graduating class of the Higher National Diploma programme implement sustainable design principles at the outset of the design process and the choices they make that may or may not provoke ecological equilibrium within the built environment. To achieve this aim the following objectives were pursued and they were meant to;

- Investigate the degree of importance students in the graduating class accorded four aspects of sustainable architecture that particularly relate to geo-climatic features of Southeast region in Nigeria; orientation, fenestration, use of shading devices, and preference for locally available building materials.
- Investigate the students' proficiencies in BIM applications.

The study was carried out based on Rostow's Modernization Theory of development which states that development in developing worlds can be attained by imitating the developmental course charted by currently developed nations (Kasanda, 2016). Education plays a crucial role in the five stages of modernization propounded in the theory in order to achieve the necessary development (Carmody, 2004).

1.1 An overview of architectural technology programme and practice in Nigeria

In Nigeria, architectural technology programmes are exclusively offered in Polytechnics and Colleges of Technology. The certificated architectural technologist is trained to assist the architect, thereby occupying the middle level manpower position in the architectural practice chain (Ob'lama, 2006; Baiyewu, Jolaoso, & Onolaja, 2007). Nonetheless, the evolution of architectural technology discipline in the UK dates back to the 1958 Oxford conference. The conference, held at Magdalen College Oxford, was organised by Sir Leslie Martin on behalf of the Education Committee of RIBA. The conference centred on; the needs of the architectural profession, means of education, avenues of entry into the profession and improvements in training and research (Roaf & Bairstow, 2008). The conference officially recognised the two-tier system, where the architects are responsible for controlling the design and the architectural technologists are in charge of providing applied skills. To emphasise this uniqueness, technologists received courses geared towards understanding the essence of design rather than merely participating in studio-based design projects (Crinson & Lubbock, 1994).

Exactly five (5) decades after the exclusive 1958 Oxford Conference, the 2nd Oxford Conference, planned to be an all-encompassing event, was organised in 2008 by Professor Susan Roaf. This second conference, albeit similar to the first in terms of the underpinning agenda, availed participants of an inclusive meeting for exchange of ideas and advancements of innovative approaches to architectural education. It also resulted in the emergence of the new agenda document, potentially capable of influencing future directions of the profession (Roaf & Bairstow, 2008). Reflections on the development of architectural technology in UK are important since the basis of the programme in Nigeria is directly traced to the British module. The architectural technologist has evolved from the earlier draughtsman role to a relatively modern profession (Cheetham & Lewis, 2001; Caplehorn, 2017). The popularity and efficiency of pre-fabricated building types used to alleviate housing challenges enhanced the advancement of technology driven designs in the building industry which birthed architectural technology as a professional discipline and consequently emphasised the responsibilities of the architectural technologist (Emmitt, 2012). With the entry of building information technology (BIM) and the constantly increasing prominence accorded the process, the role of the architectural technologist has become indispensible (Armstrong, Comiskey, & Pepe, 2013; Armstrong & Allwinkle, 2017).

Architectural practice in Nigeria is influenced on the one hand by the drive to adopt technologically advanced techniques and new materials aimed at providing solutions to existing challenges within the built up environment. Consequently, only graduate technologists proficient in computer aided design and draughting (CADD) are relevant and employed (Oladapo, 2017). On the other hand, practice is beset by constantly emerging socio-economic variables associated with ecological transitions, high population growth, urban migration, and resultant housing needs. The plethora of these problems confronting the Nigerian milieu poses a bane to architectural practice (Opoko & Oluwatayo, 2015). The estimated housing deficit of over 17 million units and a staggering record of over 100 million Nigerians living in substandard housing present a conspicuous challenge to professionals in the building industry (World Bank, 2016). Equally significant, is the fact that the country has not recorded any noteworthy milestone geared towards ameliorating the housing shortages that have become common features in many cities (Olotuah & Taiwo, 2015; Akeredolu F. , 2019). This setting is prevalent in the Southeast region characterised by high population densities and the widest spread of urban migration growth after Lagos in Nigeria, which helps to explain the explosive rise in challenges associated with the built environment that are characteristic of the region (DFID, 2004 ; Olayiwola, Adeleye, & Ogunshakin, 2005; Okhankhuele & Opafunso, 2015).

II. Literature Review

Studies have reiterated the standpoint that humanizing energy efficiency begins from the outset of design process and through the entire implementation process entails adopting a diverse approach to the design and operation. Modern building technologies that drive down cost and encourage production of affordable mass housing units that are sustainable and urgently needed in the Nigerian situation are not harnessed as approximately 90% of structures in the country are still constructed in-situ from concrete blocks (Raheem, Momoh, & Soyingbe, 2012). Majority of electricity consumers are concentrated in the building sector with residential buildings accounting for over 70% of total electricity consumption in the country (IAEA, 2014). The energy supply crisis characterised by incessant power shortages is experienced by approximately 60% of residential buildings in the country (Aliyu, Ramli, & Saleh, 2013). Clear reduction of energy necessary to cool and light buildings can be achieved by adoption of eco-friendly design techniques with efficient active systems (Arup (Madrid & Lagos offices), 2010; Rao, 2015; Prasad, Anchan, Kamath, & Akella, 2017). Many scholars have called for an urgent and complete overhaul of the architectural technology curriculum in line with design interpretation and technological advancements, and further advocated the introduction of advanced practical courses in computer applications like ArchiCAD, AutoCAD, Revit and other architectural design applications (Abdullahi, 2005; Abdulrahman & Lawal, 2007; Baiyewu, Jolaoso, & Onolaja, 2007; Dauda, Sanusi, & Ajufoh, 2010).This is crucial since one of the central issues in architectural technology education in Nigeria is the

relationship between what is taught in schools and the skill required for practice (Okpoechi, 2006; Dauda, Sanusi, & Ajufoh, 2010). The aim and objectives of the curriculum focus on producing technologists with competence in a wide range of skills and highlights fundamental design principles such as orientation, landscape, spatial arrangements and fenestrations which in the context of the Nigerian environment are key elements that promote sustainable designs.

III. Research Methodology

The survey research design was adopted in this study. Specifically, structured questionnaires were used to elicit data from the respondents that comprised the academic staff of polytechnics in the department of architectural technology and students in the graduating class of the Higher National Diploma (HND) programme. The first batch of questionnaires administered to the graduating class students concentrated on five key aspects of sustainable architecture that particularly relate to geo-climatic features of Southeast region in Nigeria; orientation, fenestration, use of shading devices, preference for locally available building materials, and preference for soft landscape as variables used to measure the students' awareness of sustainable design principles anchored on energy efficiency in relation to the environment. The aim was to discover key aspects of sustainable design principles that the students readily considered in design procedures. The second batch of questionnaires administered to the teaching staff concentrated on assessing the students' proficiencies in BIM applications.

The Southeast zone in Nigeria, which represents the study area, has five polytechnics (research population) spread across five states that constitute the zone. Based on ownership structure, three (3) out of the five (5) polytechnics are owned by the Federal Government, while the remaining two (2) are owned by respective State Governments wherein the Polytechnics are domiciled. Owing to this heterogeneous structure, the stratified random sampling was adopted in defining the samples of this research population. Two (2) homogenous groups comprising the State owned institutions and the Federal owned institutions were derived. A random sample was drawn in the ratio 1:2 for the State and Federal owned schools.

From the pilot survey conducted to investigate the number of the teaching staff in the sampled polytechnics, the result revealed that the three polytechnics had a total number of forty (40) academic staff and one hundred and forty (140) students in the final level of the HND programme. Abia State had a total of eleven (11) academic staff on roll; however, the information from pilot survey in the department, revealed that 3 out of this number were on leave of absence for further studies; hence the department was left with 8 academic staff. Federal Polytechnic Nekede had a total of fifteen (15) academic staff, and Federal Polytechnic Oko had a total of fourteen (14) academic staff. The sample size reflects the number of positive responses, and not necessarily the number of questionnaires distributed; which is often augmented to make allowance for non-response (Taherdoost, 2017). Hence, thirty-seven (37) copies of structured questionnaires were proportionately administered to the academic staff in the three departments that constituted the entire sample size for the polytechnics.

The study using the Yamane's formula adopted the approach based on 95% precision level 'e' to calculate sample size with and the population size 'N', the sample size was determined as follows (Kothari, 2012):

$$n = \frac{N}{1+N(e)^2} \qquad \text{Equation 1}$$

The total number of students in the graduating class of the Higher National Diploma (HND) programme which form the population size 'N' is 140 students. Applying the above formula, a sample size of 104 students was derived. However, with an allowance of 5% given for envisaged low response, a total of 109 copies of the questionnaires at the rate of 36 copies per department were administered to the students in the three polytechnics.

IV. Findings and Discussions

Results showed that over two-thirds (76%) of the total proportion of respondents for the first batch surveyed were males, whereas the remaining proportion accounting for less than one-third (24%) were females.

The results obtained from responses on importance of building orientation on site at the outset of their design process reveal that on a 10-point rating scale two-thirds (66%) of the respondents spread across the polytechnics rated the importance of considering orientation above the average mark. The remaining one-third (33%) of the respondents did not consider orientation as an important aspect at the outset of their design process as illustrated in Figure 1.

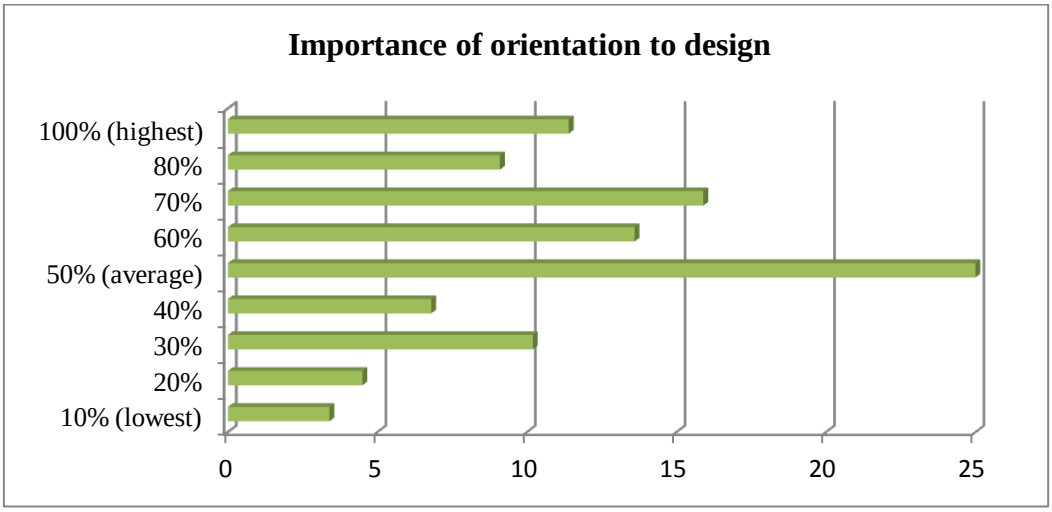

Figure 1 Importance of orientation to design

Figure 2 illustrates the spread of responses showing that over two-thirds of the total proportion of respondents indicated that they considered the position of windows and placement of shading devices important from the outset of their design process. This group were of the view that both the number of windows and the positions the windows occupy as well as incorporating shading devices contribute relatively to a reduced energy demand of the space and building at large. While close to one-quarter (24%) of respondents marked below average.

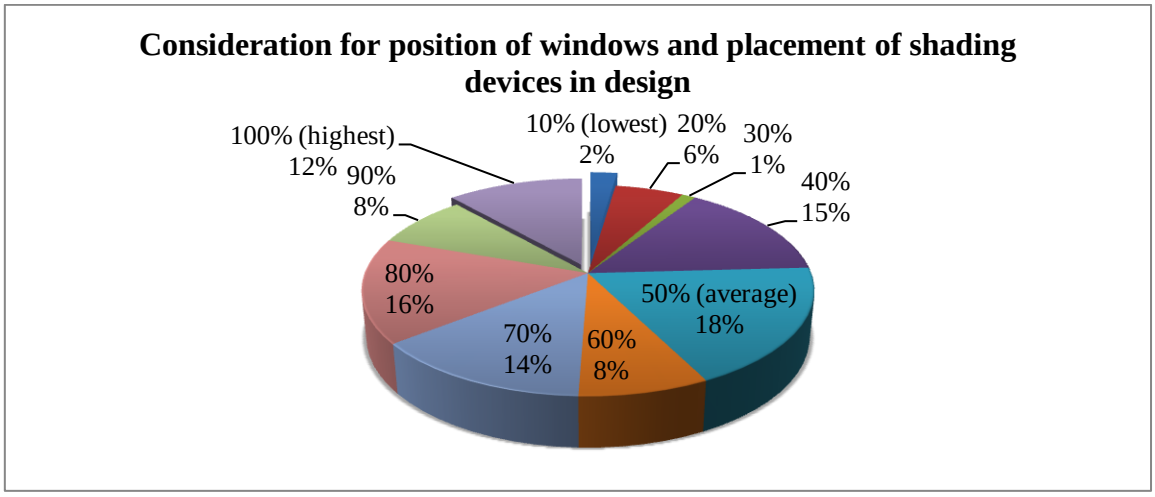

Figure 2: Consideration for position of windows and placement of shading devices in design

The results obtained from responses on preference for use of locally available building materials, reveal that a majority of the responses indicated lower ratings for use of indigenous building materials at the outset of design process as shown in Figure 3. This is reflective of the heavy preference for foreign building materials.

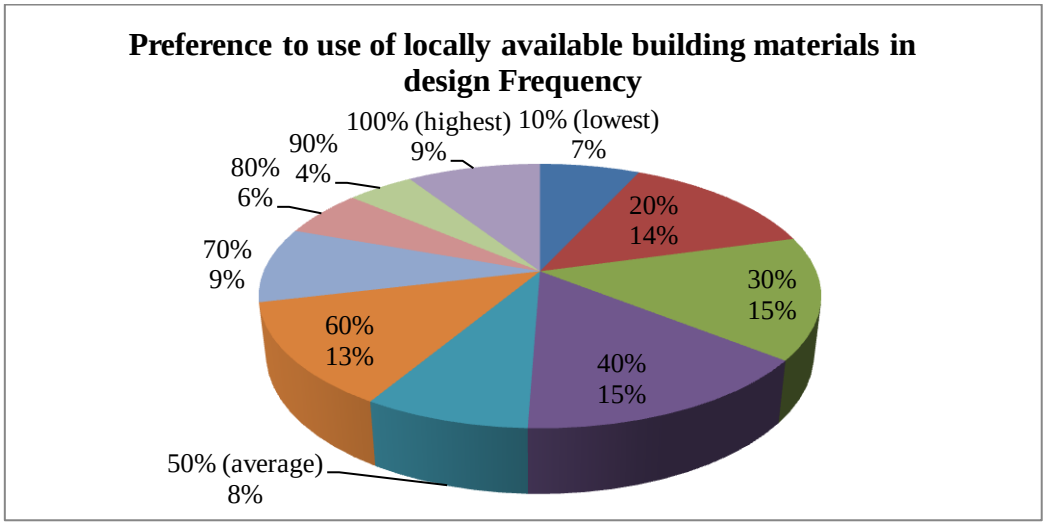

Figure 3: Preference to use of locally available building materials in design Frequency

Results of the analysis indicate that climatic conditions of the region are of utmost consideration in the conceptualisation of sustainable design. This is shown by the greater proportion of respondents that considered aspects of design principles that take advantage of bio-climatic conditions in order to enhance ventilation, visibility; the implications of which are reduced energy dependence. The use of bioclimatic design techniques reduces the energy dependency of operations such as lighting and cooling in the building. The results reveal that more students are aware of the importance of adopting design principles that collectively produce sustainable built environment.

The results of area-wise analysis revealed that approximately two-thirds of the students in the graduating class displayed basic proficiency in using BIM applications and close to one-third of the students displayed expert proficiency. The results also showed a wide margin between students in the Federal owned institutions and students in State owned institution as illustrated in Table 4.

Table 4: Area-Wise data on students' proficiency in using AutoCAD, ArchiCAD and Revit

		Name of Polytechnic		
		Federal Polytechnic Nekede	Federal Polytechnic Oko	Abia State Polytechnic, Aba
Proficiency in using AutoCAD, ArchiCAD and Revit	None	9.1%	5.7%	50%
	Basic proficiency	68.2%	62.9%	25.0%
	Expert proficiency	22.7%	31.4%	25.0%
Total		100.0%	100.0%	100.0%

V. Conclusion and Recommendations

The mounting global demand for graduates skilled in technologically advanced solution-oriented techniques coincides with evolving technological advancements in computer applications for solving man's diverse needs. The CADD applications were limited to three and the proficiency ratings showed a prevalence of basic knowledge, which is more critical in the State-owned polytechnic. The study recommends transposition of computer courses in architectural technology programmes to emphasise the relevance of exposing the students to current BIM applications. The present study shows that the importance ratings indicated by the students reflects the extent of their awareness of the basic principles of sustainable design and by extension the degree to which they are likely to implement such principles. In conclusion the paper reiterates the need to reorganise the curriculum of architectural technology programmes in the polytechnics in order to produce technically efficient technologists that can tackle the constantly evolving societal needs in the built environment.

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