RESTRUCTURING ARCHITECTURAL TECHNOLOGY CURRICULUM: The Pathway to achieving sustainable built environment in Southeast, Nigeria

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Abstract. Architectural technology programmes in Nigeria have steadily evolved with focus on enhancing local identity and environmental responsiveness to contextual issues peculiar to the Nigerian fabric. However, there remains continuous controversy as to the suitability and application of the curriculum to the emerging socio-economic and cultural needs of Nigerians. 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 as a result of shortfalls in the curriculum and paucity of adequately trained staff. Further findings revealed measures adopted for inclusive and lifelong learning in the programme include the introduction of outdoor learning environment, short entrepreneurial courses in related areas and enhanced digital literacy. 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

1. Introduction

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 [1]. 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 [2]. 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.
- Assess relevance of course contents in Entrepreneurial, Environmental, and Computer courses to inclusive and lifelong learning.

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 [3]. Education plays a crucial role in the five stages of modernization propounded in the theory in order to achieve the necessary development [4].

2. An outline 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 [5; 6]. However in Britain, the architectural technologist has evolved from the earlier draughtsman role to a relatively modern profession [7]. 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 [8]. 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. The strategic impact of architectural technology in the nexus of building technicalities and design applications supersedes other professions in the building industry [9]. The capacity of this relatively new discipline to strategically control design in relation to construction processes during the lifespan of buildings reiterates its role in addressing environmental concerns that have plagued the building industry [10]. It is important to highlight the development especially since the foundation of the programme in Nigeria mimicked the British module.

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 [11]. 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 [12]. 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 [13]. 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 [14; 15]. 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 [16; 17; 18].

3. 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 [19]. Majority of electricity consumers are concentrated in the building sector with residential buildings accounting for over 70% of total electricity consumption in the country [20]. The energy supply crisis characterised by incessant power shortages is experienced by approximately 60% of residential buildings in the country [21]. Clear reduction of energy necessary to cool and light buildings can be achieved by adoption of eco-friendly design techniques with efficient active systems [22]. 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 courses in computer applications like ArchiCAD, AutoCAD as well as entrepreneurship courses as measures to improve the quality of the contributions of architectural technologists to the professional service chain [23; 24; 6; 25; 26]. 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 [27; 25]. 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. However, the paucity of empirical studies to validate the need for reviews of the academic curriculum of architectural technology programmes being advocated by many scholars, and make reliable decisions to improve the quality of services rendered by the products have formed the premise upon which this paper developed.

4. 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 [28]. 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 [29]:

\[ n = \frac{N}{1+N(e)^2} \]  

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.

5. 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.

Table 1 shows the results obtained from responses on importance of building orientation on site at the outset of their design process. 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.
Table 1: Importance of orientation to design

| Percentage | Frequency | Percent | Valid Percent | Cumulative Percent |
|------------|-----------|---------|---------------|--------------------|
| 10% (lowest) | 3         | 3.3     | 3.4           | 3.4                |
| 20%        | 4         | 4.4     | 4.5           | 8.0                |
| 30%        | 9         | 9.9     | 10.2          | 18.2               |
| 40%        | 6         | 6.6     | 6.8           | 25.0               |
| 50% (average) | 22         | 24.2    | 25.0          | 50.0               |
| 60%        | 12        | 13.2    | 13.6          | 63.6               |
| 70%        | 14        | 15.4    | 15.9          | 79.5               |
| 80%        | 8         | 8.8     | 9.1           | 88.6               |
| 100% (highest) | 10         | 11.0    | 11.4          | 100.0              |
| Total      | 88        | 96.7    | 100.0         |                     |

Table 2 shows 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.

Table 2: Position of windows and shading devices in design

| Percentage | Frequency | Percent | Valid Percent | Cumulative Percent |
|------------|-----------|---------|---------------|--------------------|
| 10% (lowest) | 2         | 2.2     | 2.3           | 2.3                |
| 20%        | 5         | 5.5     | 5.7           | 8.0                |
| 30%        | 1         | 1.1     | 1.1           | 9.2                |
| 40%        | 13        | 14.3    | 14.9          | 24.1               |
| 50% (average) | 16         | 17.6    | 18.4          | 42.5               |
| 60%        | 7         | 7.7     | 8.0           | 50.6               |
| 70%        | 12        | 13.2    | 13.8          | 64.4               |
| 80%        | 14        | 15.4    | 16.1          | 80.5               |
| 90%        | 7         | 7.7     | 8.0           | 88.5               |
| 100% (highest) | 10        | 11.0    | 11.5          | 100.0              |
| Total      | 87        | 95.6    | 100.0         |                     |

Table 3 shows results obtained from responses on preference for use of locally available building materials, majority of the responses revealed lower ratings for use of indigenous building materials at the outset of design process. A position anchored on the premise of choice, cost indices and variety of options.

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

| Percentage | Frequency | Percent | Valid Percent | Cumulative Percent |
|------------|-----------|---------|---------------|--------------------|
| 10% (lowest) | 6         | 6.6     | 6.9           | 6.9                |
| 20%        | 12        | 13.2    | 13.8          | 20.7               |
| 30%        | 13        | 14.3    | 14.9          | 35.6               |
| 40%        | 13        | 14.3    | 14.9          | 50.6               |
| 50% (average) | 7         | 7.7     | 8.0           | 58.6               |
| 60%        | 11        | 12.1    | 12.6          | 71.3               |
| 70%        | 8         | 8.8     | 9.2           | 80.5               |
| 80%        | 5         | 5.5     | 5.7           | 86.2               |
| 90%        | 4         | 4.4     | 4.6           | 90.8               |
| 100% (highest) | 8         | 8.8     | 9.2           | 100.0              |
| Total      | 87        | 95.6    | 100.0         |                     |

Table 1: Importance of orientation to design

| Percentage | Frequency | Percent | Valid Percent | Cumulative Percent |
|------------|-----------|---------|---------------|--------------------|
| 10% (lowest) | 3         | 3.3     | 3.4           | 3.4                |
| 20%        | 4         | 4.4     | 4.5           | 8.0                |
| 30%        | 9         | 9.9     | 10.2          | 18.2               |
| 40%        | 6         | 6.6     | 6.8           | 25.0               |
| 50% (average) | 22         | 24.2    | 25.0          | 50.0               |
| 60%        | 12        | 13.2    | 13.6          | 63.6               |
| 70%        | 14        | 15.4    | 15.9          | 79.5               |
| 80%        | 8         | 8.8     | 9.1           | 88.6               |
| 100% (highest) | 10        | 11.0    | 11.4          | 100.0              |
| Total      | 88        | 96.7    | 100.0         |                     |

Table 2: Position of windows and shading devices in design

| Percentage | Frequency | Percent | Valid Percent | Cumulative Percent |
|------------|-----------|---------|---------------|--------------------|
| 10% (lowest) | 2         | 2.2     | 2.3           | 2.3                |
| 20%        | 5         | 5.5     | 5.7           | 8.0                |
| 30%        | 1         | 1.1     | 1.1           | 9.2                |
| 40%        | 13        | 14.3    | 14.9          | 24.1               |
| 50% (average) | 16         | 17.6    | 18.4          | 42.5               |
| 60%        | 7         | 7.7     | 8.0           | 50.6               |
| 70%        | 12        | 13.2    | 13.8          | 64.4               |
| 80%        | 14        | 15.4    | 16.1          | 80.5               |
| 90%        | 7         | 7.7     | 8.0           | 88.5               |
| 100% (highest) | 10        | 11.0    | 11.5          | 100.0              |
| Total      | 87        | 95.6    | 100.0         |                     |

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

| Percentage | Frequency | Percent | Valid Percent | Cumulative Percent |
|------------|-----------|---------|---------------|--------------------|
| 10% (lowest) | 6         | 6.6     | 6.9           | 6.9                |
| 20%        | 12        | 13.2    | 13.8          | 20.7               |
| 30%        | 13        | 14.3    | 14.9          | 35.6               |
| 40%        | 13        | 14.3    | 14.9          | 50.6               |
| 50% (average) | 7         | 7.7     | 8.0           | 58.6               |
| 60%        | 11        | 12.1    | 12.6          | 71.3               |
| 70%        | 8         | 8.8     | 9.2           | 80.5               |
| 80%        | 5         | 5.5     | 5.7           | 86.2               |
| 90%        | 4         | 4.4     | 4.6           | 90.8               |
| 100% (highest) | 8         | 8.8     | 9.2           | 100.0              |
| Total      | 87        | 95.6    | 100.0         |                     |
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.

| Name of Polytechnic          | Federal Polytechnic | Federal Polytechnic | Abia State Polytechnic, Aba |
|------------------------------|---------------------|---------------------|----------------------------|
| Proficiency in using AutoCAD| None                | 9.1%                | 5.7%                       |
|ArchicAD and Revit            | Basic proficiency   | 62.9%               | 25.0%                      |
|Total                         | 100.0%              | 100.0%              | 100.0%                     |

The results of the analysis in Table 5 revealed that more than half of the responses comprised of academic staffs that teach the courses agreed that the course contents in Entrepreneurial and Environmental courses promoted inclusive learning. Two-thirds of the respondents from this group agreed that the course contents in Computer courses promoted inclusive learning. The remaining one-third of the respondents comprised the group that were either uncertain or disagreed that the contents promoted lifelong and inclusive learning as illustrated in Table 5.

| Value label       | Valid Percent | Cumulative Percent | Valid Percent | Cumulative Percent |
|-------------------|---------------|--------------------|---------------|--------------------|
| Strongly Disagree | 6.9           | 6.9                | 20.0          | 20.0               |
| Disagree          | 13.8          | 20.7               | 10.0          | 30.0               |
| Uncertain         | 20.7          | 41.4               | 3.3           | 33.3               |
| Agree             | 34.5          | 75.9               | 43.3          | 76.7               |
| Strongly Agree    | 24.1          | 100.0              | 23.3          | 100.0              |
| Total             | 100.0         |                    |               |                    |

6. 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 restructuring of computer courses in architectural technology programmes to expose 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. The findings further revealed that some
courses promote lifelong learning, hence availing students of the opportunities for self-improvement irrespective of gender, social status or age. In conclusion the paper reiterates the longstanding call on the need to restructure 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. This is critical at this period, when sustainable built environment is no longer an option.

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