Contents lists available at

Journal of Environmental Management and Safety

Journal homepage: www.cepajournal.com

A Study of Energy Efficiency Issues in Architectural Design Studios: *A Case Study of Obafemi Awolowo University, Ile – Ife, Osun State*

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ARTICLE INFO

Article history
Received 20 July, 2015
Received in revised form August 1, 2015
Accepted 13 August, 2015
Available online 25 December, 2015

Keywords:
Energy Efficiency, Architectural Design Studio,Learning Outcome, O.A.U,Ile Ife.

ABSTRACT

Energy efficiency plays an important role in ensuring a conducive studio-based learning environment for architecture students. This paper therefore, assesses energy efficiency issues of architectural design studios in Nigeria's universities. This was with a view to determining the performance appraisal of the design studio facilities in the architectural studio of Nigerian universities.The primary source of data for this study was collected through a self-administered questionnaire designed to examine the following attributes: student's background characteristics; visual and thermal comfort of architectural studio; learning environment and attendance; Impact of architectural design studio facilities on students learning outcome. The analysis of data collected was accomplished by the use of Statistical Package for Social Science (SPSS) software. Data collected were subjected to both descriptive and inferential statistics. The assessment of the visual and thermal comfort of the architectural studios reveals majority (76.6%) of the respondents considered the level of ventilation in their design studio as adequate compared to (23.4%) who claimed the level of ventilation was inadequate despite the fact that majority (68.5%) of the respondents claimed there was no alternative built in power source in their design studio in the event of power outage from the public supply. In addition, significant proportion of the respondents, approximately (76.0%) support the claim that studio environment generally affects their learning outcome, while the remaining (24.0%) did not support the claim.The regression analysis to examine the impact of architectural design studio facilities on students learning outcome shows that only two predictor variables namely; acoustic ($p=0.001<0.05$) and studio quality ($0.028<0.05$) had their associated p-value to be less than the alpha threshold value and were found to have impact on learning outcome.The paper provides a logical approach for appraising the major performance requirements of an architectural design studio. Emphasis was majorly on the thermal, visual and acoustic comfort of the architectural design studio. Its importance to design professionals, facility providers/managers gives uniqueness to this study.

1.0 Introduction

Energy efficiency, thermal and visual comforts are of concern in studio design. Architectural design studio is a place of learning where architecture students can work comfortably during the normal class and studio hours. On the other hand, students have given right to pursue their own design projects out of formal class hours too (Stamps, 1994 and Demirbas, 1997). Nevertheless, it could be an ideal space that encourages both of the above ideas at any given time. This is the environment where architectural students spend most of their time, sometimes talking to each other, but mainly absorbed in a parallel, private pursuit of the specified design task (Schön, 1987). Stamp (1994) further claimed that about one third to one half of educational time is spent in the design studio by the students.

Since valuable learning occurs as a result of student interactions, the designs of these spaces must include a variety of areas where students can interact, consult and socialize (Kuh et al, 2005; Chism, 2006). According to Deasy and Lasswell (1985), a learning environment functions both as a learning space and a complex social organization. The role of the studio in architectural education is very important. It has been suggested that approximately one third or half of the educational process of architectural students is spent in the studio (Stamps, 1994).

The twenty-first century is seeing greater emphasis being placed on student-centered learning approaches. Corresponding with this direction of thinking is the need for learning spaces to be designed to be flexible so that they can be used simultaneously by different groups. With respect to issues that need to be considered when designing learning environments, the involvement of intended users of the space (staff and students) during the design process is important. Other considerations include functionality, adjacencies (referring to connections to other people and spaces), physiological and psychological aspects, furnishings, group size and structural aspects (Temple, 2007).

This study is therefore significant in that it will add to the body of knowledge regarding energy issues of architectural design studios and students' perceptions on design for architecture studio in the Nigerian universities context. Also, the findings would provide a clear sense of design direction especially related to, thermal and visual comforts, acoustic comforts, fire safety and crowding issues for architecture design studio in both public and private colleges and universities. Thus, designers will need some guideline to create positive studio environment since students' learning outcome is greatly affected by the design condition of studio setting and the facilities put in place to aid such learning process. The specific objectives are to:

a. examine the thermal and visual characteristics of architectural design studio;
b. assess the relationship between studio environment and learning outcome; and

c. examine the impact of architectural design studio facilities on students learning outcome.

2.0 Literature Review

The most fundamental course in architectural education is design, as students transform the practical and theoretical knowledge gained, with their creativity in the representation of a design model (Schön, 1994, 1997). Architectural programme has been modeled on design studios that focus on practical education. In fact, design studios are considered the hub of architectural learning. It can be considered as the most crucial space in the architectural educational study.

The design studio in architectural education is one of the renowned and most commonly used spaces for developing, evaluating and exhibiting collections of art and design works (Duggan, 2004). Design studio environments serve both as a learning center and as a multi-faceted social setting. Students enrolled in design courses usually work in these spaces during their free times, in addition to their scheduled class hours (Demirbas and Demirkan, 2000). Architectural design studios are becoming a significant resource for enabling students to gain applied and theoretical knowledge that could be transformed with creativity into design solutions.

Likewise, they also serve as a resource for developing and upgrading the level of practical knowledge especially computer-based drafting among the students of programs like architecture, architectural engineering and planning. Institutions around the world have become progressively more conscious of the need for continuous assessment of their educational facilities for architectural design. Recently, several studies have focused on exploring the role of the architectural design studio to prove its value as a significant resource to academic institutions. And, as a result, several schools of architecture or the built-environment are endeavoring now on means to improve their design studios in a way that respond to changes in the nature of higher education and different life style needs of the students (Duggan, 2004).

Previous studies on performance appraisal of educational facilities indicate that comfort of architectural design space is a significant aspect to be considered and maintained for the success of the architectural education process. And as such, academic institutions are aiming to provide design studio spaces that are comfortable and conducive for collaborative learning.

2.1 The Concept of Learning Environment

Studies about students' academic achievement and building condition conclude that the quality of the physical environment significantly affects student achievement. 'There is sufficient research to state without equivocation that the building in which students spends a good deal of their time learning does in fact influence how well they learn' (Earthman, G., 2004:18).

Desirable designs include having 'friendly and agreeable' entrance areas, supervised private places for students, as well as public spaces that foster a sense of community, with particular attention to the colour used (Fisher, K., 2000 in McGregor, J., 2004:2). Today's schools must create spaces that students want to go to, similar to the way cafes attract people, rather than the space being purely functional (Bunting, A., 2004:12).

According to (Lang, 2005), the physical learning environment should not be constructed to influence teaching or learning styles but should be responsive to individual student and teacher needs. These physical surroundings in the learning environment impact perceptual learning, concept formation, language development, socialization, creative growth, attitudes towards school, reduction of vandalism, and attrition rates in schools (Lackney, 1999b.).

The learning environment is made up of the physical surroundings present in a learning situation (Barker and Garvin-Doxas, 2004). These ambient factors are created by the commonly identified features of lighting quality, indoor air quality (IAQ), noise management, and size (Lackney, 1999a*et al;* Lang, 2005 and Chan, 1996)**.** Several additional physical features are integral to the learning environment. Chan (1996) suggests that the aesthetic qualities in a building are part of the learning environment.

Lang (2005) describes the components of these aesthetic qualities. Lewis (1995), Earthman (2002), and Chan (1996) emphatically present the factor of facility condition as a component of the learning environment. Heath and Mendell (2002), Lackney 1999a, *et al*), and Lyons (2002) stressed the criticality of indoor air quality (IAQ) as a key component of the learning environment. The very center or focal point of the learning environment is the classroom.

3.0 Research Methodology

The survey research design was adopted for this study. The population for this study covers all students from the Department of Architecture, Faculty of Environmental Design and Management, Obafemi Awolowo University, Ile Ife. The selection for participants in this survey exercise was limited to students who have spent at least one semester. The primary source of data for this study was collected through a self-administered questionnaire that assess the thermal and visual characteristics of architectural design studio, relationship between studio environment and learning outcome and impact of architectural design studio facilities on students learning outcome.

In order to ensure maximum responses to the questionnaires, respondents were briefed regarding the purpose of the survey and reassured that the information provided will be kept confidential and will be used for research purposes only. A total of one hundred and fifty (150) questionnaires were randomly administered across the

selected studios (studio 2-4) and the postgraduate studios. Out of this number, 124 valid questionnaires were retrieved, representing a response rate of (82.7%). A Likert scale ranged from "1" = very dissatisfied, "2"=dissatisfied, "3"= satisfied, "4"= very satisfied, was used to measure respondents' level of satisfaction on various design studio facilities.

3.1 Data Analysis

The analysis of data collected was accomplished by the use of Statistical Package for Social Science (SPSS) software. Data were analyzed using descriptive statistics such as frequency distribution and percentages and inferential statistics such as multivariate regression analysis. The multivariate regression was used to predict the impact of each of the predictor parameters (design studio facilities) on the dependent variables- learning outcome and studio attendance.

4.0 Results and Discussion

4.1 Background Characteristic of Respondents

Before going into the research objectives, the background attributes of the respondents need to be examined. The personal attributes examined are gender, age group and level. The gender distribution of the sample indicates that (62.9%) of them were male while (37.1%) were female. The proportion of respondents in the age group 25-31 years was (51.6%) while those in the age group 18-24 years were (34.7%). Respondents in the age group 32-39 years accounted for (13.7%).

Simple majority (37.1%) of the respondents who participated in the study were postgraduate students, (29.0%) were from the 300 Level class, (16.1%) from the 200 Level class and (17.7%) from the 400 Level class. Summary of the background characteristics of the respondents is presented in table 4.1.1.

Table 4.1.1: Respondents background characteristics

Gender	Freq	%	Age Group	Freq	%	Level	Freq	%
Male	78	62.9	18-24 years	43	34.7	200L	20	16.1
Female	46	37.1	25-31 years	64	51.6	300L	36	29.0
			32-39 years	17	13.7	400L	22	17.7
						PG	46	37.1
Total	124	100.0	Total	124	100.0	Total	124	100.0

Source: Authors' Fieldwork, 2015

4.2 Visual and Thermal comfort of Architectural Design Studio

Comfort can defined as the maintenance of thermal balance between human body and the environment. Opoko (2001) submits that the fundamental function of buildings is the protection of man from the vagaries of inclement weather while Ogunsote (1991), explains that knowledge of nature of comfort is essential in design

with the aim of maintaining comfort within buildings.

Ventilation is the replacement of used inside air by the outside air. The ventilation condition inside building is among the primary factors determining health, comfort and wellbeing. Umoh (2000) buttresses this saying that primary factors have a direct effect on the human body through the physiological effect of air purity and motion and an indirect effect through their influence on the temperature and humidity of indoor air and surfaces.

However, Natural Ventilation is the ventilation achieved without mechanical aids, but by stacks effect and wind pressure. Cross ventilation is the ventilation achieved by placing openings in opposite walls of an enclosure. Olotuah (2001) cautions that the dwelling units should be planned so as to facilitate thorough ventilation as the deterioration in the physio-chemical properties of the indoor atmosphere can adversely affect the comfort of the occupants. He stressed further that ventilation has three distinctly different functions namely; supply of fresh air, convective cooling (structural ventilation) and physiological cooling.

For the purpose of assessing the visual and thermal characteristics of architectural studio, the students were asked to evaluate some important attributes that could affects the visual and thermal comfort of the architectural studio. The response from the students as presented in (Table 4.2.1) reveals that majority (52.4%) of the survey respondents claimed the number of students allocated per studio was between 41-50 students, (33.9%) claimed between 31-40 students are allocated per studio, while (13.7%) claimed over 61 students are allocated per studio.

However, majority (76.6%) of the respondents considered the level of ventilation in their design studio as adequate compared to (23.4%) who claimed the level of ventilation was inadequate. It was also observed that fan was the only alternative source of ventilation in the design studio as supported by (75.8%) of the total respondents surveyed. Contrary to previous claim, just (8.1%) of the surveyed respondents rate the general quality of ventilation in their design studio to be good, (34.7%) rated it as fair, while simple majority (43.7%) rate the general quality of ventilation in their design studio as poor.

Further assessment reveals that majority (68.5%) of the respondents claimed there was no alternative built in power source in their design studio in the event of power outage from the public supply. Among respondents who claim there was alternative power source, (66.9%) claimed they never get supply from the only available alternative power source (generator) in their design studio.

Table 4.2.1 Visual and characteristics of architectural design studio

Number of students allocated per studio?	**Freq**	**%**
31-40	42	33.9
41-50	65	52.4
61 and above	17	13.7
Total	124	100.0
How Adequate is the level of ventilation in your studio?		
Very Adequate	44	35.5
Adequate	51	41.1
Inadequate	17	13.7
Very Inadequate	12	9.7
Total	124	100.0
What is the alternative source of ventilation in your studio?		
Fan	94	75.8
None	30	24.2
Total	124	100.0
General quality of ventilation		
Good	10	8.1
Fair	43	34.7
Poor	54	43.5
Very poor	17	13.7
Total	124	100.0
Alternative built in power source		
Generator	39	31.5
None	85	68.5
Total	124	100.0
How often do you get supply from the alternative source in the events of power outage from the public supply?		
Occasionally	19	15.3
Always	9	7.3
Seldom	13	10.5
Never	83	66.9
Total	124	100.0

Source: Authors' Fieldwork, 2015

4.2.2 Studio Characteristics / Attendance

The general condition of the design studio can greatly affects student's attendance and ultimately determines how long they decide to stay. Findings from the survey reveal that majority (60.5%) of the respondents spent between 4-6 hours per day in their design studio. It was also observed that significant proportion (65.3%) of the

students surveyed work in their design studio at night. Among respondents who claim to work in their design studio at night, (29.8%) spent above 6 hours, (25.0%) spent between 4-6 hours, while (10.5%) spent between 1-3 hours of work in their design studio at night. With respect to reasons for not working in the design studio at night, (24.2%) claim they just don't feel like, (19.4%) gave poor lighting system as their reason for not working at the design studio at night, while (10.5%) claimed unstable power supply.

Table 4.2.2 Studio characteristics and attendance among architectural students

Number of hours spent in studio during the day	**Freq**	**%**
1-3 hours	49	39.5
4-6 hours	75	60.5
Total	124	100.0
Do you work in your design studio at night?		
Yes	81	65.3
No	43	34.7
Total	124	100.0
How long do you spend working in your studio at night?		
1-3 hours	13	10.5
4-6 hours	31	25.0
above 6 hours	37	29.8
Not applicable	43	34.7
Total	124	100.0
Reason for not working in studio at night?		
It is not allowed	2	1.6
Just don't feel like	30	24.2
Poor lighting system	24	19.4
Unstable power supply	13	10.5
Not applicable	55	44.4
Total	124	100.0

Source: Authors' Fieldwork, 2015

4.3 Architectural Design Studio and Students Learning Outcomes

It has been noted that room temperature, air quality, glare, noise, lighting, seats comfort and possibilities of arrangement have a great effect on the standards of teaching and learning in design studio (Obeidat *et al*, 2012). Some other issues that need to be considered when designing these learning spaces are functionality, flow between spaces, and the connections of people using those spaces. Other aspects that need to be considered are the size of the groups using the space, the involvement of the staff and students

who will be using the space, structural aspects, as well as psychological and physiological aspects (Temple, 2007). During the design process, it is important to have input from the intended end-users of the design space (Sanoff, 1993).

Table 4.3.1 Studio environment and learning outcome

Studio environment generally affects my learning outcome	**Freq**	**%**
Strongly agree	64	51.6
Agree	30	24.2
Disagree	10	8.1
Strongly disagree	20	16.1
Total	124	100.0
My departmental studio does not encourage effective design work		
Strongly agree	14	11.3
Agree	44	35.5
Disagree	43	34.7
Strongly disagree	23	18.5
Total	124	100.0
My departmental studio is usually overcrowded and does not favour effective design work		
Strongly agree	19	15.3
Agree	26	21.0
Disagree	42	33.9
Strongly disagree	37	29.8
Total	124	100.0

Source: Authors' Fieldwork, 2015

According to table (4.3.1), significant proportion of the respondents, approximately (76.0%) support the claim that studio environment generally affects their learning outcome, while the remaining (24.0%) did not support the claim. However, findings from the survey data further reveals that (53.2%) of the respondents disagreed with the claim that their departmental studio does not encourage effective design work, while (46.8%) support the claim.

Similar to initial claim, majority (63.7%) of the respondents did not support the claim that their departmental studio is usually overcrowded and therefore does not favour effective work design, while (36.3%) supported the claim that their departmental studio is usually

overcrowded and does not favour effective design work.

4.4 Impact of Architectural Design Studio Facilities on Students Learning Outcome

Previous studies had shown that design studio facilities affect students learning outcome. According to (Obeidat *et al,* 2012), room temperature, air quality, glare, noise, lighting, seats comfort and possibilities of arrangement have a great effect on the standards of teaching and learning in design studio.

The regression analysis to examine the impact of architectural design studio facilities on students learning outcome is presented in table (4.4.1). In other to assess the statistical significance of the model, it is necessary to look in the ANOVA value. This tests the null hypothesis that the predictors variables (design studio facilities) are not statistically significant in predicting the dependent variable (learning outcome). The model in this case reached statistical significance (F=4.490, p = .001<0.05). In other words, this model is statistically significant. To check for the predictor variables that are statistically significant, their associated p-value were examined. As shown in (table 4.5.1), only two predictor variables namely; acoustic (p=0.001<0.05) and studio quality (0.028<0.05) had their associated p-value to be less than the alpha threshold value and were found to have impact on the dependent variable. The co-efficient of multiple determinations (R^2) provides an explanatory power of the regression model. From our result, the co-efficient of multiple determination value (R^2=0.238) indicates that the predictor variables (design studio facilities) are accounting for approximately (24.0%) variation on the learning outcome.

Table 4.4.1 Regression analysis of the impact of architectural design studio facilities on students learning outcome

	Unstandardized Coefficients		Standardized Coefficients		
Variables	B	Std. Error	Beta	t	Sig.
(Constant)	-2.325	2.130	-	-1.091	.277
Visual comfort	-.060	.125	-.066	-.481	.631
Thermal comfort	.086	.088	.135	.972	.333
Acoustic comfort	.292	.065	.587	4.454	.001
Fire safety	.042	.038	.128	1.101	.273
Studio quality	.098	.044	.269	2.223	.028
Interior finish	.051	.097	.050	.522	.603
Brainstorming space	-.131	.104	-.150	-1.266	.208
Support service	.009	.092	.015	.103	.918
ANOVA (F=4.490, p=0.001) R^2=0.238					

Independent variable: Learning outcome

Source: Authors' Fieldwork, 2015

5.0 Conclusion and Recommendation

This study examines energy efficiency issues in Nigeria universities architectural studio (OAU as a case study). The architectural design studio is considered to be the space where students of architecture work, consult with, engage in formal interactions with one another as well as display their projects during exhibitions and jury examinations. Therefore, the realization that the transfer of knowledge does not only take place in the four walls of the classroom from the teacher to the students but rather that learning takes place through discovery, exploration, interaction with the internal and external environment has necessitated the creative and innovative development of teaching and learning facilities that reflect these changes.

The findings from this study shows that students learn design skills in the studio space, therefore the use of the studio for architecture education is crucial and the design studio can be considered a specialized form of learning space. This study therefore plays a significant role in contributing to design knowledge and provides blue print both for improving existing design studio condition as well as for designing a new one.

The regression analysis to examine the impact of architectural design studio facilities on students learning outcome shows that only two predictor variables namely; acoustic ($p=0.001<0.05$) and studio quality ($0.028<0.05$) had their associated p-value to be less than the alpha threshold value and were found to have impact on learning outcome. This findings can be used by lecturers or administrators to take appropriate measures to streamline the efforts towards providing conducive learning environment for architecture students taking into consideration the acoustic comfort which is has often been the barrier to effective learning outcome in design studios. Policymakers and designers should be concerned about the relationship between design studio facilities and student learning outcome, not only because of health, security, and psychological issues, but also because the failure to create and maintain optimum learning environments can undermine other efforts to reform education.

Acknowledgement and Appreciation:
The authors wish to acknowledge the construction professionals and contractors for their responses to questionnaires and for participating in the survey and the sources of secondary data used in this study and appreciate all the authors that had done the previous works that provided platform for the discussions in this paper. The authors also wish to thank the three anonymous reviewers of the paper for their constructive comments, valuable guidance and advice.

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