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Users' Experience of Lighting Design in a Deep-Plan Office Building: Case of Federal Polytechnic Ede Administrative Office Extension Osun State

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Abstract – Lighting design in office building has been noted to incorporate both daylight and artificial strategies in most cases. These approaches are informed to a large extent by the building design. The design factors such as building form, function and size alongside other environmental and climatic considerations impacts lighting design; and consequently, the lighting quality experienced by users of such buildings. A deep plan office building pose challenges of poor illumination or lighting inadequacy when not properly addressed. User experience of lighting has been carried out in form of evaluation, assessment or post occupancy evaluation studies in most developed countries. However, information on user experience of lighting in a deep plan office building is very limited in tropical climate area like Nigeria. This study therefore assesses users' perception of lighting design impacts in the administrative office building extension of the Federal Polytechnic Ede, Osun State. The study combines field observation and subjective evaluation approach using structured questionnaire survey. Due to small study sample population in total of 103 occupants, 50% sample size equivalent of 51 respondents was used. Only 43 questionnaires were retrieved. Data obtained were subjected to descriptive statistics using statistical package for social sciences (spss). Finding shows that the majority of the respondents 24 (55.82%) hold the view that the quality of lighting is rather dim.

Keywords: Deep-plan Office, Field observation, Lighting, Lighting design, Lighting impacts, User experience

1. Introduction

Lighting is indispensable provision for any workplace because it aids clarity of vision, easy task performance, safety at work, and greatly impact on health and well-being. Lighting design in office building has been noted to incorporate both daylight and artificial strategies in most cases. This is to provide uniform illumination over the entire workplace and enhances sustainability and energy efficiency in such buildings. These strategies are informed to a large extent by the building design. The design factors such as building form, function and size alongside other environmental and climatic considerations impacts lighting design; and consequently, the lighting quality experienced by users of such buildings. Besides, building codes and regulations provide design guide for lighting in buildings world over (Doshi and Dugar, 2015). Although, strict adherence to codes has been observed to hamper the design aesthetics, and bear no sensible relationship to providing users satisfaction (Doshi and Dugar, 2015). Good lighting design inside office buildings can provide the visual and psychological requirements of office workers (Bean, 2012).

Deep-plan office design has been observed to pose challenges of poor illumination or lighting inadequacy when not properly addressed. A deep plan building is considered as a building with a plan depth exceeding the passive zone (Hansen, 2006). Passive zone in energy efficient building is described as the area in the building that can be daylit and naturally ventilated. The depth of the passive zone is usually limited to twice the ceiling height. Other view about a deep plan building says it is a building with unobstructed open plan of more than 17m. The depth creates a non-passive zone which needs artificial lighting and ventilation. Deep plan buildings rely on artificial lighting. Their reliance on electrical lighting has several direct and indirect detrimental effects which include unproductive and unhealth environment to mention few (Hansen, 2006). Existing research asserts that poor indoor environmental quality such as lighting has a detrimental effect on human health, and in case of the office working population, it also affects their work performance (Katabaro and Yan, 2019).

Relevant and available empirical study on assessment of workplace lighting impacts has revealed its dimensions to consist of physiological, psychological, task performance, safety, health and well-being (Castillo-Martinez et al, 2018). However, the study was done in Spain, a developed country. Investigating users experience of lighting in a deep plan office building is of high significance. Office tasks performance whether paper document processing or digital documentation have high visual requirements. For such activities, lighting is an important factor to facilitates user-task vision without difficulties or discomfort, increases productivity, and reduces accident risk and fatigue (Castillo-Martinez et al, 2018). According to Ibem *et al*, (2013) this type of study can provide information that will improve the quality of design, construction and management of buildings and by extension, promotes sustainable built environment

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2 Literature

2.1 *Lighting design*

Lighting design in office building has been noted to incorporate both daylighting and artificial strategies in most cases. Day/Natural lighting, wherever available forms a major factor in architectural design decisions and among the various fields of environmental comfort and energy efficiency in buildings (Castanheira, and Souza, and Fortes, 2015). Building form, function, dimensions, and other architectural features (particularly glazing properties) are paramount factors that influence the design of natural lighting in buildings. Ascertaining good daylighting design in building therefore requires juxtaposing these factors properly from the design stage (Castanheira, and Souza, and Fortes, 2015).

Lighting design in office buildings has so well employed side daylighting strategies through windows for daylight harvesting and for view of outside environment (Huang, Niu, & Chung, 2014). This has proven to be most sustainable and effective system for improving visual comfort (Hourani & Hammad, 2012); as well as reducing energy consumption for lighting (Gago, Muneer, Knez, & Köster, 2015). However, literatures have pointed out limitations in daylighting application for office activities. These include: the requirement for appropriate lighting levels for safety and well-being of the occupants at all times of the day (Hourani & Hammad, 2012; Huang, Niu, & Chung, 2014), need for visual contact with the outside and a glare-free indoor space (Castanheira, and Souza, and Fortes, 2015). Besides, issue with vertical windows is that even with a 100% glass area wall, light is unlikely to exceed 6m in distance from the window (Kevin Van Den & Meek, 2015). As a result, there is a high contrast between the area next to the window, and deeper areas in the buildings (BSI, 2011).

This necessitate incorporation of artificial lighting to support effective performance of indoor activities.

Artificial lighting design offers solution to some of the challenges of natural lighting especially with the constant level of illuminance throughout the day. Artificial lighting design in traditional work setting emphasized mainly the visibility on desks surface (i.e. task light). The workplace lighting design is generally based on task light which affords switching from the illumination over a large area to areas such as desk. A task light can be oriented to a place, allowing the user to manage its direction and area of incidence according to his needs (Osram.com, n.d.). However, transformation in the working methods from paper to computer has encouraged reduction of horizontal illuminance levels which has now been incorporated into lighting design guide (Preto and Gomes, 2019).

The study by Preto and Gomes (2019) reported other office lighting requirements which essentially describe the properties of light. These include: lighting spectrum, colour temperature, lighting levels, direction of light, and aesthetics and trendy parameters (Preto and Gomes, 2019). Spectral quality is a complex term used to show how warm or cool a light is. It is measured by two concepts which are; Correlated Colour Temperature of light, (CCT) and Colour Rendering Index (CRI). Lighting levels at 1.000 lx is recommended at certain period of the day especially the morning hour. Also, light direction required that it should be vertical (directly on the eye) rather than horizontal (on the table or desk). In most offices, lighting design is supported by aesthetical and trendy parameters overlooking human non-visual lighting needs (Preto and Gomes, 2019). In general, workplace lighting design is based on task light. This allows switching from the illumination over a large area to areas such as desk. It also enables orientation of light as suitable for the user need.

Artificial lighting and modernity have been essentially linked. There is no doubt about its benefits, it enables users to increase the activity in spaces through light quality and also creates a welcoming feeling, making it possible to increment the night activity while reducing crime at the same time (Preto and Gomes, 2019).

Lighting design generally employs range of standards, codes and recommended practice documents as useful tools guiding current lighting practice (Doshi and Dugar, 2015). Parameters, such as illuminance and colour temperature are quantitative indexes used to calculate and assess office lighting design. There exist two school of thoughts guiding lighting design practice- “best practice” designers and “architectural” designers. Typically, this divide is informed by the attitude of the lighting professional to lighting standards. The “Best practice” designers’ emphasis on lighting standards to do their job of devising installations that are fully compliant to meet requirements for visibility (Doshi and Dugar, 2015). “Architectural” designers on the other hand focuses more on the appearance instead of visibility, and therefore find it absurd to cite lighting standards on illuminance uniformity as a measure of quality.

2.2 *Lighting Impacts*

Impacts of lighting on office workers range from physiological, psychological, task performance, health and well-being (Castillo-Martinez et al, 2018). Studies have outlined ways lighting in the workplace may influence employee performance. These entail eye strain (dryness, itching, or burning) and visual comfort; cognitive performance and problem-solving ability through interference with physiological factors like circadian rhythms (Castillo-Martinez et al, 2018). The impacts of poor lighting on workers task performance are observed in high

chances of error, slower pace of work and distortion of natural working position which may result in musculo-skeletal strain (Doshi and Dugar, 2015).

Moreover, psychologically, lighting affects mood and attitude. Association of daylighting with improved mood, enhancement of morale, fatigue reduction, and reduction of eyestrain have been established (Castillo-Martinez et al, 2018). The seasonal depression is considered as obvious evidence to prove the relationship between natural light and human endocrinal system. Wang & Boubekri, (2009) affirms the association of daylight and workers' subjective well-being; and employees' preference for working near the windows or with natural lighting.

Importance of lighting in office building has been recognized with respect to vision clarity, task performance, safety at work, influence on health and well-being (Castillo-Martinez et al, 2018). Good lighting aids vision, recognition and distinguishing of objects in terms of shape, size and colour. Office tasks performance whether paper document processing or digital documentation have high visual requirements. For such activities, lighting is an important factor to facilitates user-task vision without difficulties or discomfort, increases productivity, and reduces accident risk and fatigue (Castillo-Martinez et al, 2018).

Good lighting design inside office buildings can provide the visual and psychological requirements of office workers (Bean, 2012). In addition, Dubois et al. (2011) holds the view that good lighting design can significantly diminish overall electric consumption of office buildings.

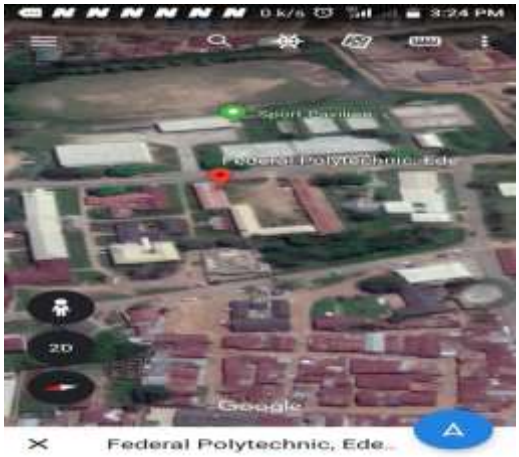
3 Materials and Method

3.1. Description of the building and location

This study focuses on the administrative building extension of the Federal Polytechnic Ede, Osun State. It is located on geographical coordinates of 7º 44'20" N, 4º 26'10" E. The building has dimensional coverage of about 30x26.7m in maximum of four floors including the basement. It is a deep plan partitioned office building. Assessment of the design reveal a partial sensitivity to the need of daylighting in its conception,

see figure I.

The spatial configuration of the building favours daylighting harvesting along its perimeter, while the spaces at the core area lack good accessibility to daylighting. Window design are majorly combination of sliding and projected windows at a very good height of about 2.1m. some of the spaces along the perimeter are provided with internal shading/blind (curtain).



(a) (b)

Figure 1 a & b: Satellite Images (Aerial view and Administrative building extension) of the Federal Polytechnic Ede, Osun State

Figure 2: Western Elevation

Figure 3: North-western Elevation

Figure 4: North-south elevation

Figure 5: Typical partitioned office

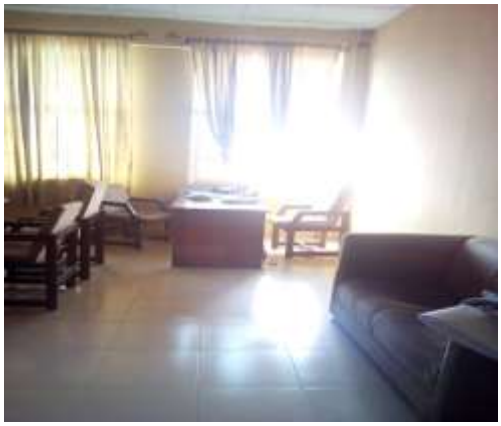


Figure 6: Glare in the office space

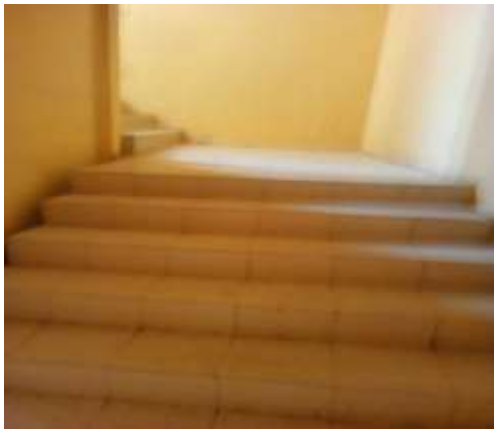


Figure 7: Illumination at the staircase

3.2 Methodology

User experience of lighting has been carried out in form of building evaluation, appraisal/assessment or post occupancy evaluation studies in the literature (Gopikrishnan and Topkar, 2015; Deb, and Kalluri and Kondepudi and Parikh and Sastry, 2013). Users experience/perception of lighting design was investigated through combined methods of field observation and subjective evaluation approaches using structured questionnaire survey. This follows Dianat, Sedghi, Bagherzade, Jafarabadi and Stedmon (2013) that used a questionnaire to determine the satisfaction with the lighting in work environment. For instance, a survey question reads: "How satisfied are you with the lighting condition in your work environment?" Participants had to answer on a five-point scale from very low until very high. The questionnaires in the current study were randomly distributed for good representation of users' opinions. The enquiries were rated on three to five likert scale. Out of the sample population of 103 workers in the administrative building extension, 50% sample size was used equal total of 50 questionnaires. Only 43 questionnaires were retrieved. The field observation by the researchers took records of daylighting and artificial lighting design, building design parameters and window types. The data obtained was subjected to descriptive statistical analysis.

4 Findings and Discussion

4.1 *Respondents' socio-economic characteristics*

Respondents' gender analysis reveals that, 23 (53.49%) are female and 20 (46.51%) are male. The highest educational attainment of respondents indicates 30 (69.77%) as holder of HND/BSc degree. Moreover, 27 (62.8%) of the respondents have worked in the studied building for between 0-5 years. The commonest nature of work perform in the building shows highest of 18 (41.86%) engaging in desk paper work, while 13 (30.23%) work on computer.

4.2 *Lighting design, work performance, visual comfort and well being*

Assessment of lighting design in the studied building indicates highest as combination of both natural and artificial lighting to the tune of 33 (76.74%) and area serviced with strictly artificial lighting indicates 10 (23.26%).

Table 1: How adequate is natural lighting in your office

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Highly adequate	16	37.2	37.2	37.2
	Quite adequate	22	51.2	51.2	88.4
	Barely adequate	3	7.0	7.0	95.3
	Not adequate	1	2.3	2.3	97.7
	Highly inadequate	1	2.3	2.3	100.0
	Total	43	100.0	100.0	

Source: Authors' field work, 2019.

23 (53.49%) respondents were of opinion that the natural lighting in the building is adequate, which is the highest. On the control of natural light, 19 (44.19%) submit that it is sufficiently controlled. This is obvious from that provision of curtain as window blind.

The major type of artificial lighting fitting used in the building is energy saving bulb of different watts. As observed in the study, the original lighting fitting used were fluorescent. This later paved way to energy saving fitting as a response to energy efficiency advocacy.

Table 2: Describe the quality of electric lighting in your office

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Too high	16	37.2	37.2	37.2
	Dim	23	53.5	53.5	90.7
	Too low/poor	4	9.3	9.3	100.0
	Total	43	100.0	100.0	

Source: Authors' field work, 2019.

The majority of the respondents 23 (53.5%) informed that the quality of lighting fitting is rather dim. This could have resulted from insufficient fittings in relation to floor area of each office space.

Field observation also reveal a case of one "pawpaw shape bulb" per office. Those whose desk is far from the centre will definitely be deprived of proper illumination especially in none passive zone.

Table 3: How does your office lighting enhance your task performance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Highly enhanced	18	41.9	41.9	41.9
	sufficiently enhanced	17	39.5	39.5	81.4
	Barely enhanced	6	14.0	14.0	95.3
	Not enhance	1	2.3	2.3	97.7
	Highly unenhanced	1	2.3	2.3	100.0
	Total	43	100.0	100.0	

Source: Authors' field work, 2019.

Respondents up to 18 (41.86%) agreed that their office lighting highly enhance their task performance. 22 (51.16%) experience sufficient comfort working under such lighting provision.

Table 4: How frequent do you experience/complain on visual health problem?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very often	4	9.3	9.3	9.3
	Often	6	14.0	14.0	23.3
	Moderately	5	11.6	11.6	34.9
	Less often	11	25.6	25.6	60.5
	Not at all	17	39.5	39.5	100.0
	Total	43	100.0	100.0	

Source: Authors' field work, 2019.

On visual health issues, 17 (39.53%) notes that they do not have any of such challenge or complain while 4 (9.30%) have severally experienced visual health impairment at one time or the other.

Table 5: How does the lighting contribute to safe movement within the building?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Highly safe	22	51.2	51.2	51.2
	Sufficiently safe	13	30.2	30.2	81.4
	Moderately safe	5	11.6	11.6	93.0
	Slightly safe	2	4.7	4.7	97.7
	Highly unsafe	1	2.3	2.3	100.0
	Total	43	100.0	100.0	

Source: Authors' field work, 2019.

The highest response rate on safety of movement shows 22 (51.16%) who claimed to be highly safe and 20 (46.51%) agreed that artificial lighting fittings of the building are highly accessible for control.

5 Conclusion

Assessment of lighting design in the administrative building extension of the Federal Polytechnic Ede reveals the office activities to be more of desk paper work than computer work. The reported situation whereby about 50% of the users work comfortably with the provided lighting remains irreconcilable with the report by greater number of the same set of users who indicated that artificial lighting design in the building is dim. Future study requires objective/quantitative evaluation of lighting quality in the building for confirmation of results obtained. Due to the climatic advantage of the study location, Architects who handles design of office buildings should endeavor to maximize the use of natural lighting design strategies.

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