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Users' Perception of Artificial Lighting in Interior Spaces: A Case Study of Office Buildings in F.U.T, Akure, Nigeria

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Abstract
Lighting is a significant component in interior design due to its ability to enhance aesthetic value and create the feeling and ambience of a living space. The perception of a user is also an important factor to consider when designing the lighting of a space. Seventy (70) questionnaires were administered, and fifty-nine (59) were retrieved for analysis, with a response rate of 84.29%. These were analyzed using Statistical Package for the Social Sciences (SPSS, version 2021). Data gathered were analyzed using percentage, tables, Dendrogram, K Means, Two-step cluster analysis, and Factor Analysis. The study found that artificial lighting causes glare in some offices having too much intensity for an enclosed space which means that distribution factor may not be considered in computing the number of luminaries. Also, office spaces get dark when all artificial lights are switched off, this is caused by inadequate natural lighting, and positioning of windows. Furthermore, users of the spaces find artificial lighting encouraging and energizing and suggest that change of wall colors and redesign of artificial lighting fixtures based on the task to perform were the major ways to improve the lighting situation in office spaces. This study recommends that natural lighting should be adequately considered when designing a building for visual comfort. Also, the task to be performed in such interior spaces should be ultimately considered during the design of the artificial lighting fixtures.
Keywords: Architecture, Artificial lighting, Interior design, Users Perceptions, Office buildings
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1.0 Introduction

Interior space is produced by the people who occupy it and influenced by those who design and produce it. An interior space that makes the client feel disconnected, wobbly or awkward to utilize is as a result of taking care of every one of these components separately. Also, the aesthetics of a space is dependent on how well the designer utilizes its form. Interior spaces require light so that users may feel safe, and the occupants have a comfortable visual environment that enhances the performance of visual tasks. Artificial lighting is provided for situations where daylight is insufficient to meet these needs.

Illumination is the thoughtful use of light to achieve functional or appealing effects which could be realized by natural or artificial means. Lighting is important in architectural designs as it helps to change the ambience of a space as well as the perceived size of an enclosed area. Lighting is a significant component in interior design due to its ability to enhance aesthetic value and create the feeling and ambience of a living space (Anj, 2020). It includes both natural and artificial light sources like: lamps and light fixtures, as well as natural illumination by capturing daylight. Daylighting (using windows, skylights, or light shelves) is sometimes used as the main source of light during the daytime in buildings which reduce energy consumption. Proper lighting can enhance task performance, improve the appearance of an area, or have positive psychological effects on occupants. The application of lighting in architectural designs largely focuses on the use of light for the sake of brightening or illuminating a space. Whereas, artificial lighting offers a variety of purposes and functions that aid the non-verbal communication as well as the psychological aspects of exterior and interior of building and space designs (Sholanke, Fadesere and Elendu, 2021). The proper use of lighting is very important when designing office spaces. Lighting has a long lasting effect on individuals and how they relate with others and as such should be correctly utilized in order to maximize its effects in this regard (Sholanke*et al,* 2021). Sometimes there is a wrong interpretation of how the lighting should be placed, what type of lighting fixture should be used, and the type of lighting systems. Lighting in public buildings is vast as there are different types of public buildings with different functions and as the functions differ, so does the perception of users differ.

The perception of a user is also an important factor to consider when designing the lighting of a space. Humans perceive things differently. What may seem beautiful to an individual may not be the same for another. Therefore, the effect of lighting in a space when perceived by individuals invokes a different reaction. An office is a place where official activities are carried out, and the way in which architects and designers create these spaces for their clients will impact people's daily lives, as well as the lives of the users. Lighting has an influence on our psychological wellbeing, and the subtle information offered by the perceptual qualities of light are the ones stimulating spatial experiences and sensations such as satisfaction, safety, comfort, relaxation and stress (Kronqvist, 2010). The lighting design of interior spaces should be satisfactory for both functional and

psychological perception (Koen, 2015). In architecture today, artificial lighting has evolved beyond spatial illumination over the years to become a tool for non-verbal communications that can affect people emotionally and psychologically. From observations, most of the office spaces at the Federal University of Technology, Akure (FUTA) have been found to exhibit ineffective artificial lighting due to the design of the spaces, therefore how this affects the users of the space and their general performance level will be studied. The growing knowledge of the influence of lighting on office staff has heightened the need for further studies (Kronqvist, 2010).

2.0 Literature Review

2.1 Lighting Design for Interior Spaces

The lighting design of interior space should be satisfactory for both functional and psychological perception (Oyeleye and Makanju, 2021). Providing adequate or quality lighting condition in a working space goes beyond the act of just installing a suitable quantity of light. Köhler (2013) discussed the importance of studying light, color and illumination from an integral point of view because the manifestation of these three factors lead to the physiological and psychological relationships that would in turn define requirements and design of the style of lighting. Köhler (2013) also presented general requirements for lighting, referring to lighting as an artistic instrument that influences people psychologically. This requirement is mainly based on the task being performed in the space. Illumination levels in a space should correspond with the minimum lux/lumen level for various tasks based on recommended standards. It also depends on aesthetic considerations, mainly dealing with harmony, and the uniformity of illumination. Although intentional differences are acceptable and even required in certain areas, a soft transition is desirable. Shading and incidence, recognition of shapes and forms, depend largely on their perception resembling natural shading as viewed in daylight. Distortion of shapes or appearance as silhouettes is a result of false shading. Color of light is essential to suit the color in the room and obtain desired color renditions. This effect has been noted to affect the psychological as well as aesthetic. Glare results largely from excessive brightness differentials in the field of vision and should be avoided both in the form of direct glare from lamps and fixtures as well as reflected glare from illuminated objects.

2.2 Lighting Control and Productivity in Office Spaces

There are links between perceptions of control, user comfort and increased self-reported levels of productivity. Although the ability of personal lighting controls to improve productivity in a directly measurable sense may be questioned, there are few doubts that they can promote comfort (Moore, Carter, and Slater, 2012). Moore further explained that there is also evidence that lighting perceived as poor can be demotivating and adversely affect productivity, and a way to improve an individual's perceptions of their environment is the devolvement of control over them.

The lighting level affects the level of a person's alertness and the incidence of work errors. Lower levels of lighting can cause fatigue, thereby reducing work speed (Boyce, 2019). Bright lighting is useful for improving the alertness and mood of workers during working hours (Zhu, 2019) compared to lamps providing light of a lower intensity. The higher the lighting level and the color temperature of the lamps, the more suitable the illumination is for people in areas which require their functionality whereas the relaxation area can apply a low light temperature color (Van, 2008).

In offices, as with other workplaces, lighting is needed so that the occupants can see to carry out their work tasks quickly, accurately and easily (Boyce, 2011). Boyce further explained that there are three routes whereby the visual environment, and thus lighting, can influence task performance: by changing the visibility of the task (the visual system), by changing the mood of workers and hence their motivation to do the task (the perceptual system) and by stimulating greater alertness (the circadian system). Consideration of all three aspects is needed to ensure a visual environment that maximizes productivity, i.e. one that provides good visibility of tasks, that stimulates the staff and that promotes the well-being of staff, without discomfort or demotivating perceptions such as gloom (Fotios, 2011).

2.3 Perception of Users in Interiors of Public Buildings using Artificial Lighting

The interior environment has a powerful ability to generate emotions and those emotions influence users' perceptions of service quality (Bell, 2008). Surfar, Talib and Hambali (2012) explained perception of the environment, in its strictest sense, refers to the process of becoming aware of a space by the acquisition of information through the sensations of sight, hearing, smell, touch, and taste. Cognition is the mental processing of this sensory information. This may involve the activities of thinking about, remembering, or evaluating the information. Spatial behavior refers to responses and reactions to the environmental information acquired through perception and cognition. All these are important in determining the perception of the user in particular environment in this case it been to artificial lighting. In providing the visual comfort conditions that enhance visual perception in interior spaces, the quantity and quality of lighting, and the surface properties on which the

light reflects gain importance (Erkurk and Ormecioglu, 2018). Frontczak, Schiavon, Goins, Arens, Zhang and Wargocki (2012) study reported that the size of a space, as a spatial quality component, was ranked as the most important for a user's environmental satisfaction in the workplace.

Steidle and Werth (2013) posits that lighting conditions can be viewed as an environmental resource (at the workplace) if they facilitate task performance or boost mental resources, for instance, if a pleasant lighting elicits positive mood and motivates to work perseveringly.To describe and create psychologically sustainable lighting conditions, it is important to understand how lighting conditions impact user's performance and well-being. These routes of influence can be explained associating the different levels of comfort with well-established psychological mechanisms (Vischer, 2007), these level of comfort are discomfort, physical comfort, functional comfort, and psychological comfort. Here, comfort is understood not merely as thermal or visual comfort. Instead, comfortable rooms or lighting conditions should support user's well-being, satisfaction, and performance (Steidle and Werth 2013).

3.0 Research Methodology

Data of the study were collected with the aid of a well-structured close ended questionnaire administered to the respondents, and through direct observations. The quantitative method was used as the methodological approach through the use of surveys. This generated numerical data in terms of total number of respondents, socio-demographic characteristics and results. The questionnaire survey includes distributing questionnaire to 70 lecturers who own private office spaces in the School of Environmental Technology, FUTA. The offices are designed facing each other with a common corridor of 1.5m wide and the offices not well ventilated and illuminated because of the positioning of the windows and the doors at the corridor. The office spaces differ in sizes, the smallest is about 2m by 2.4m range and the largest is 3m by 3m which is a single user office.

The questionnaire is in three sections, the first section investigates respondents profiles and demographic characteristics, the second section explores the respondents' perception to the use of artificial lighting that are available in the office space, and the third section determines the level of comfort of users due to the type of artificial lighting provided in the office space. The data obtained determined users' perception to artificial lighting. Seventy (70) questionnaires were administered, and fifty-nine (59) were retrieved for analysis, with a response rate of 84.29%.

4.0 Findings and Discussions

Various statistical tools were deployed for the data analysis and research findings. The completed questionnaires were examined and information for each item on the questionnaires were processed through the use of Statistical Package for the Social Sciences (SPSS, version 21). The data gathered were analyzed using percentages, tables, Dendrogram, K Means and Two-step cluster analysis, and Factor Analysis.

Table 4.1 shows the gender of the respondents. The result reveals that 32.2 percent of the respondents were females and 67.8 percent were males. This may imply that majority of the staff members in the offices are males.

Table 4.1: Gender of respondents

Variables	Frequency	Percent
Male	19	32.2
Female	40	67.8
total	59	100

Researcher's Compilation, 2022

Table 4.2 shows the age group of the respondents. The result reveals that 28.8 percent are between 21-40 years, 61percent are between 41-60 years and 10.2percent are between 61 and above, this is because the university environment is youth-friendly therefore a good number of the lecturers are young.

Table 4.2: Age Group of respondents

	Frequency	Percent
21-40yrs	36	28.8
41-60yrs	17	61.0
61 and above	6	10.2
total	59	100

Researcher's Compilation, 2022

Table 4.3 shows the number of respondents or how many staff members occupy an office space. The result reveals that 28.8percent are one staff office space occupiers, 37.3percent are two staff office space occupiers, and 33.9percent are three and more staff office space occupiers. This shows that there are adequate numbers of offices for staff members which are divided according to positions held.

Table 4.3: How many staff occupy an office space

	Frequency	Percent
One	17	28.8
Two	22	37.3
Three and more	20	33.9
Total	59	100

Researcher's Compilation, 2022

Table 4.4 shows the perception of users to the lighting system available in the office space. The ranking indicates that most respondent's perception of artificial lighting is different and most of the respondents believe that it causes glare, Office spaces get dark when all artificial lightings are switched off. Artificial lighting are stimulating with a mean item score of 2.31, 2.08 and 2.03 respectively. This is followed by artificial lighting affects visibility, artificial lighting creates better lighting conditions, office spaces need to be well lit and lighting affects mood with mean item score of 2.00, 1.81, 1.64 and 1.58 respectively. From these results, it can be deduced that glare has the highest mean to the perception of the lighting system and lighting affecting mood has the lowest mean score. This could imply that artificial lighting design in the offices under consideration does not conform to International commission on lighting (CIE) standards, and this is in agreement with the findings of Katabaro and Yan (2019) who worked on effects of lighting quality on working efficiency of workers in office buildings in Tanzania. The study noted that occupants are less satisfied with the lighting quality in their working environment, which significantly affected their work efficiency and wellbeing. Average desk luminance and uniformity levels were found to be below the recommended values of the Chartered Institution of Building Services Engineers (CIBSE) and the International Commission on lighting (CIE).

Table 4.4: Perception of Users to the Lighting System Available in the Space

	Mean	Rank
Artificial lighting causes glare	2.31	1
Office spaces get dark when artificial lighting is off	2.08	2
Artificial lightings are stimulating	2.03	3
Artificial lightings affects visibility	2.00	4
Office spaces need to be well lit	1.64	5
Lighting affects mood	1.58	6
Artificial lightings create better lighting condition	1.81	7

Researcher's Compilation, 2022

Factor analysis was also used to assess the perception of users to the lighting system available in their office spaces. This analysis is intended to explore and detect underlying relationships among the variables and describe them in fewer, but in more concise and comprehensive terms. The significant factors with MS> 3.00 were reduced to principal Component with factor analysis as put forward by Khalid (2010) and Yap (2013).

For sampling adequacy test, the Kaiser-Meyer-Olkin (KMO, 0.743) in Table 4.5 show that data collected were adequate for the analysis and the Bartlett's test of sphericity for correlations adequacy between the variables was highly significant. Kaiser-Meyer-Olkin(KMO) measure of sampling adequacy of data gathered on assessment of the correlation matrix shows that these listed items have significant correlation at the 5% level and therefore exploratory factor analysis is appropriate. The KMO explain that 80% of the data gathered were adequate and it explain how suited the data is for factor analysis. It measures the sampling adequacy for each variable considered and the complete model on the ways working environment can be improved to increase productivity. Since the values fall around 0.743(74.3%), it indicates that the sampling is adequate for factor analysis. Barlett's Test of Sphericity indicates whether a data or the sampling considered can be suitable for factor analysis. Having performed the analysis, it could be shown that **P**- value considered is< 0.05 which implies that the data is suitable for factor analysis with degree of freedom of 21 and an approximate chi-square of 95.204. For this data, Bartlett's test is significant (**P**- value = 0.000), suggesting that the correlation is an identity matrix which means that the correlation matrix shows that the items listed have significant correlation at 5% level with the perception of the users, therefore exploratory factor analysis is appropriate.

Table 4.5: KMO and Bartlett's Test for Perception of Users to the Lighting System Available in the Space

Kaiser-Meyer-Olkin Measure of sampling Adequacy		.743
Bartlett's Test of Sphericity	Approx. Chi-Square	95.204
	Df	21
	Sig.	.000

Researcher's Compilation, 2022

Table 4.6 shows the initial matrix and the extracted matrix of squared loadings result for the perception of

users to the lighting system available in their office space. The second, third and fourth columns (Total, %Variance, Cumulative %) are initial matrices; the next three columns to the right are the rotated matrix only when the Eigenvalue is greater than 1. The total variance explained by each factor is listed in the second column labeled total/initial Eigenvalue. In the third column, the factors are arranged in descending order of variance as explained. In the third column from Table 4.6 below, the first two (2) items have a cumulative variance of 59.06% which implies that the remaining (5) items account for only the remaining 40.94% of variance.

Table 4.6: Total Variance Explained for Perception of Users to the Lighting System Available in the interior Spaces

	Initial Eigenvalue			Extraction sums of squared loadings		
component	**total**	**%of variance**	**Cumulative%**	**total**	**% of variance**	**Cumulative %**
1	2.863	40.896	40.896	2.863	40.896	40.896
2	1.271	18.159	59.055	1.271	18.159	59.055
3	.840	12.003	71.058			
4	.740	10.573	81.631			
5	.469	6.706	88.337			
6	.436	6.229	94.566			
7	.380	5.434	100.000			

Researcher's Compilation, 2022
Extraction Method: Principal Component Analysis.

	Component	
	1	**2**
Artificial lighting affects visibility	.797	
Artificial lighting causes glare	,742	
Office spaces gets dark when all artificial are switched off	.727	
Artificial lighting are stimulating	.693	
Office spaces need to be well lit	.511	
Lightings affects mood		.814
Artificial lighting creates better lighting conditions		.736

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

From Table 4.7, a model with two items may be adequate to represent the perception of users to the lighting system available in their office space. The factor grouping based on the varimaxrotation is shown in Table 4.6. Each variable weighs heavily on to only one of the factors, while the loading on each factor exceeds 0.30. The high communalities also indicate that the extracted components represent the variables well. Stevens (2009) cited in yap (2013) recommends interpreting only factor loading > 3.0 for substantial importance of a variable to a factor. Therefore, factor loading < 0.3 are not displayed in Table 4.6.

Before interpretation of the two (2) extracted physical components, it is essential to name these factors. The naming is subjective. It depends on the background and training of the analyst. There is no specific scientific procedure for naming the factors as shown 4.7.

Therefore, the thoughtful naming of these factors was deemed to be appropriate for this study. Each factor is labeled and interpreted as follows: i. Artificial lighting effect ii. Artificial lighting benefits.

Table 4.7: Reduced Components for Perception of Users to the Lighting System Available in the interior Space

S/N	**Factor components**	**Variables**	**Factor loading**
1	Artificial lighting effect	Artificial lighting affects visibility	.797
		Artificial lighting causes glare	.742
		Office spaces gets dark when all artificial switches are off	.727
2	Artificial lighting benefits	Artificial lighting are stimulating	.693
		Office spaces need to be well lit	.511
		Lighting affects mood	.814
		Artificial lighting creates better lighting conditions	.736

Researcher's Compilation, 2022

Artificial lighting effect, being the first component explained that this principal factor account for 40.90% of the observed total variance and it contains three (3) items. The items are: S Artificial lighting affects visibility (sig. = 0.797), Artificial lighting causes glare (sig. = 0.742) and Office spaces get dark when all artificial switches are off (sig. = 0.727).

The second principal factor is Artificial lighting benefits with 18.16% of the total observed variance and contains four (4) items which can be regarded to as the perception of users to the lighting system available in their office space. The items are; Artificial lighting are stimulating (sig. = 0.693), Office spaces need to be well lit (sig. = 0.511), Lighting affects mood (sig. = 0.814) and Artificial lighting creates better lighting conditions (sig = -0.736).

5.0 Conclusion and Recommendation

This paper examined the impact of artificial lighting in interior spaces and the perception of its users. The study found that artificial lighting causes glare in some offices having too much intensity for an enclosed space that does not conform to CIE standards. Also, office spaces get dark when all artificial lights are switched off, this is caused by inadequate natural lighting, positioning of windows and inconsistency in power supply.

Adequate circulation with the artificial lighting, and positioning of the artificial lighting were the major comfortability type of artificial lighting in the office space; this shows that users of the space find artificial lighting encouraging and energizing. Change of wall colors and increase in the uniformity factor were the major ways to improve the lighting situation in office spaces. Based on the conclusions drawn, this study further recommends that;

1. The various aspects of physical interior environments and interior ambience should be considered: such as space layout, selection of furniture, lightings, material finishes, and air quality. Space ambience, thermal comfort and acoustics too.
2. The needs of the end users are paramount and should be put into consideration in great details when designing artificial lightings for public buildings.

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