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Research paper

OPTIMISATION OF DAYLIGHTING STRATEGIES IN EDUCATIONAL LEARNING ENVIRONMENTS IN NIGERIA: A CASE FOR UNIVERSITY LIBRARY DESIGN

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Abstract

Natural daylighting is a sustainable and cost-effective technique for improving indoor environmental quality in educational buildings, particularly in tropical regions such as Nigeria. University libraries, as centres of knowledge and extended student activity, require excellent visual comfort and low energy consumption. The aim of this study is to analyse and optimise daylighting systems in Nigerian university libraries in order to increase learning outcomes, user satisfaction, and energy efficiency. The objective is to improve the lighting conditions in libraries by implementing efficient and controlled daylighting systems. The research methodology used was a mixed-method approach that included quantitative assessments using questionnaires (n=168) for data collection and case studies of selected university libraries in Nigeria. The study examines current design approaches, daylight availability, and occupant responses. The findings revealed that it is more favourable to consider the use of passive daylighting techniques for library design as a natural way of lighting to create a pleasant environment in libraries and incorporate them into various types of libraries in Nigeria. This would improve users' comfort, reduce the usage of artificial lighting, and increase the energy efficiency of library buildings. The significant of this study is that the outcome would provide appropriate guidance for architectural design decisions and regulatory frameworks that promote daylight-responsive library architecture in Nigerian universities.

Key words: *Daylighting, Education, Learning Environments, Library Design, University, Nigeria*

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1. INTRODUCTION

Daylighting is vital in learning environments such as libraries, where users rely on consistent, evenly dispersed light to complete activities efficiently. According to Flynn *et al.* [1], lighting design has a dramatic impact on human visual experience by guiding movement, directing focus, and changing perceptions of space. Building on this, Rahman and Tuhin [2] emphasise that daylighting is more than just an architectural decision; it is a critical environmental quality that influences user comfort, productivity, and building energy consumption in educational settings. In Nigeria, unstable electricity and high energy prices make daylighting both difficult and advantageous. Despite ample sunlight, many university libraries rely extensively on artificial lighting due to poor architectural design, which increases energy costs and reduces visual comfort. Inadequate daylighting can cause glare, discomfort, and thermal imbalance, all of which interfere with users' ability to complete jobs effectively.

This research tackles these concerns by investigating how spatial orientation, window design, daylight control technologies, and material selection might improve daylighting in university libraries. Its goal is to: (i) Evaluate the effectiveness of current daylighting initiatives in chosen Nigerian university libraries. (ii) Investigate how library illumination affects user pleasure, productivity, and health. (iii) Develop optimal daylighting solutions for new and retrofitting university library designs in Nigeria. Following these goals, the study aims to improve visual comfort, energy efficiency, and overall user satisfaction through optimal daylighting optimisation.

2. LITERATURE REVIEW

Extensive research has shown that daylighting in educational buildings improves visual comfort, cognitive function, mood, well-being, and energy efficiency [3-5]. Notably, Samani *et al.,* [6] discovered that natural light increases reading comprehension and lowers eye strain, while Rahman & Tuhin [2] emphasise its importance in aligning circadian rhythms to promote attention. Optimal daylighting solutions include proper building orientation, window sizing and location, light shelves, clerestories, and advanced glazing [7]. In tropical climates, extra measures such as shading devices, solar-control films, and responsive lighting controls are required to reduce heat gain. Nigeria, with its abounding sunlight, is a significant design opportunity. However, local studies show that university libraries frequently suffer from poor daylight utilisation due to deep floor plans, insufficient window placement, and a lack of daylight control, resulting in an overreliance on artificial lighting and compromised comfort [8-10]. Few post-occupancy evaluations exist, and there is an urgent need for context-specific empirical assessments. Empirical research supports the link between daylight and academic outcomes: Kano classrooms with optimised windows showed a 12-15% increase in test results [11]. Though research on academic libraries is scarce, recent studies indicate that daylight improves reading comfort, circulation flow, and concentration [12]. Despite clear global evidence, there is little documentation on (i) daylighting performance in Nigerian university libraries, (ii) how design parameters (orientation, glazing, shading) relate to actual user comfort and health, and (iii) the use of post-occupancy evaluations and daylight simulations for optimisation. This indicates an important research need: empirical assessments to drive context-specific daylighting methods for Nigeria's educational environments.

3. RESEARCH METHODOLOGY

3.1 Study Location

The study was carried out in Niger State, which is located in North Central Nigeria. Niger State is home to various tertiary educational institutions, including the Federal University of Technology, Minna (FUTMinna), Ibrahim Badamasi Babangida University, Lapai (IBBUL), Niger State College of Education, Minna, and Newgate University in Minna. These institutions were chosen because they have a mix of federal, state, and private ownership and provide various learning environments with varying architectural designs and daylighting tactics in their library buildings. The choice of location enables a comparative investigation of the influence of daylighting in university libraries across various educational environments.

3.2 Research Design

The study used a quantitative cross-sectional survey research design. The method is appropriate for collecting perceptual and experience data from a large number of respondents at a single time [13]. A comprehensive, pre-tested questionnaire was developed and distributed to students and academic staff at the selected institutions. The instrument looked at crucial characteristics like library usage patterns, light source preferences, availability to lighting controls, perceptions of visual comfort, and the psychological consequences of lighting in library environments.

3.3 Population of the Study, Sampling Technique and Sample Size

The target population consisted of academic library users from four selected institutions in Niger State. These included undergraduate and postgraduate students, pre-degree students, lecturers, and non-academic personnel who frequented the library for a variety of reasons, including reading, research, studying, and using ICT resources. The demographic was chosen based on their likelihood of using both natural and artificial lighting systems in university libraries. A purposive sample strategy was employed to choose library users who have extensive experience using their institution's library facilities. This strategy was appropriate for targeting individuals who were most likely to provide credible insights regarding daylighting circumstances and their effects on user experience and productivity [14]. A total of 168 valid responses were gathered from the four institutions selected. This sample size is deemed appropriate based on Kotrlik *et al.'s* [15] recommendations of a minimum of 160 respondents for populations greater than 1,000 at a 95% confidence level and a 5% margin of error.

3.4 Research Instrument

The primary data gathering tool was a structured questionnaire designed to evaluate the use, accessibility, suitability, and impacts of daylighting in university libraries. The questionnaire comprised of both close-ended and Likert-scale items, which were divided into the following sections: (A) Demographic and institutional profile (B) Library usage patterns (C) Natural vs. artificial lighting preferences (D) Lighting control accessibility (E) Illumination adequacy and uniformity (F) Visual comfort and safety (G) Psychological and mood responses to lighting. The measure was created using reviewed literature in daylighting and environmental psychology Boyce [16] and Li & Tsang [5], verified through expert review in architectural lighting, and pilot-tested for dependability.

3.5 Method of Data Collection and Data Analysis

Over a four-week period, questionnaires were delivered both physically and electronically in the libraries of the selected institutions. Physical administration was aided by research assistants who delivered brief instructions to participants. Online versions were produced with Google Forms and distributed via university email lists and WhatsApp platforms to maximise reach. Participation was optional and anonymous, and all respondents provided informed consent. Only anyone who have utilised the library in the previous 12 months were eligible to answer the questionnaire. The acquired data was coded and analysed using Statistical Package for the Social Sciences. (SPSS) Version 25. The replies were summarised using descriptive statistics including frequencies, percentages, mean scores, and standard deviations. In addition, the Relative Importance Index (RII) was utilised to rate judgements of daylighting sufficiency, visual comfort, and mood effects. Cross-tabulation was utilised to investigate the association between demographics (e.g., level of study or staff category) and lighting preferences. The data analysis supported conclusions about the optimisation potential of daylighting solutions in Nigerian educational library environments.

4. RESULTS AND DISCUSSION

A total of 200 questionnaires were provided; however, only 168 of them were properly completed and returned. This equated to an 84% response rate. This response rate is relatively high, hence the response rate obtained for this study is judged adequate for the analysis, as any survey result with a lower response rate of 30-40 percent is skewed and of lesser significance [17].

4.1. Background characteristics of the respondents

Table 1 shows the characteristics of the questionnaire respondents. A large number of them were students, with only a small percentage working at those institutions.

As can be seen, 35.1% of respondents are from COE, 33.3% from FUT, and 30.4% from Newgate University, with only 1.2% coming from IBBU Lapai. 86.9% are undergraduate students, 6.6% are lecturers, 5.4% are pre-degree students, and 1.2% are master's students. There are 33.3% 100 Level (L) students, 19.6% 500L students, 19% 300L students, and 16.7% 200L students. 3.6% are 200L, 1.2% are Masters students, and 6.5% are academic personnel. The poll also revealed that 51.8% are women and 47% are men. 69.6% are between the ages of 16 and 26, 19.6% between 26 and 36, 8.3% between 36 and 46, and 2.4% between 46 and 56 years old. These findings reveal a well-defined, mostly undergraduate population, with balanced gender representation and a high age concentration in the 16-26 cohort. However, caution should be exercised when extending the findings to postgraduate users or the under-represented IBBU Lapai group.

Table 1. Background characteristics of respondents

Characteristics of Respondents	Frequency	Characteristics of Respondents	Frequency
Institution		**Level (L)**	
FUT	56 (33.3)	100L	56 (33.3)
IBBU	2 (1.2)	200L	28 (16.7)
COE	59 (35.1)	300L	32 (19)
New-gate	51 (30.4)	400L	6 (3.6)
		500L	33 (19.6)
		Postgraduate	2 (1.2)
		Academic staff	11 (6.6)
Status		**Gender**	
Student	157 (93.5)	Male	79 (47)
Staff	11 (6.5)	Female	87 (51.8)
		Prefer not to say	2 (1.2)
Status in the institution		**Age**	
Pre-degree	9 (5.4)	16-26	117 (69.6)
Undergraduate	146 (86.9)	26-36	33 (19.6)
Postgraduate	2 (1.2)	36-46	14 (8.3)
Lecturer	11 (6.5)	46-56	4 (2.4)

4.2. Adequacy of daylight strategies employed in library design

Table 2 displays the suitability of daylight strategies used in the design. Respondents to the survey thought the lighting conditions in the library were good. Specifically, 42.9% assessed the provision of natural light as 'very adequate' and 35.1% as 'extremely adequate,' with only 10.7% expressing displeasure; the mean score of 2.0 confirms that natural lighting is mostly effective. Similarly, consistency of illumination garnered positive comments, with 39.9% rating it 'very adequate' and 28.0% 'quite adequate', and only 10.1% unsatisfied. The corresponding mean of 2.16 indicates that lighting is sufficiently consistent for reading and studying. Finally, 38.1% of respondents rated indoor lighting as 'very adequate', 25.0% as 'extremely adequate', and only 25.0% as 'barely adequate', as seen by a somewhat higher mean of 2.24, showing space for improvement. These findings indicate that, while daylight provision and homogeneity match user needs, certain interior zones could benefit from enhanced lighting interventions."

Table 2. Uniformity of illumination for performing library activities

Level of adequacy	The provision for natural lighting	Uniformity of the illumination	Illumination of the indoor environment
Highly adequate	35.1%	28.0%	25.0%
Quite adequate	42.9%	39.9%	38.1%
barely adequate	11.3%	22.0%	27.4%
Not adequate	8.3%	8.3%	6.5%
Highly inadequate	2.4%	1.8%	3.0%
Mean value	2.0	2.16	2.24

4.3. Impact of library illumination on user's satisfaction

Table 3 depicts the impact of illumination on user satisfaction. Emotional Impact reflects the respondents' happiness and unhappiness. The mean happiness level for 49.4% (29.2% highly, 20.2% high) is 3.45. The mean for high dissatisfaction when there is insufficient light is 3.66. This means that proper daylighting considerably improves consumers' mood, whereas insufficient lighting causes severe discontent.

Table 3. Impact of illumination on User's satisfaction.

Variable	Level of agreement	Frequency (percent.)	Mean value	Variable	Level of agreement	Frequency (percent.)	Mean value
The lighting condition makes me happy when reading	Lowest	19(11.3)	3.45	I feel relaxed when using the library	Lowest	16(9.5)	3.36
	Low	18(10.7)			Low	29(17.3)	
	Medium	48(28.6)			Medium	42(25)	
	High	34(20.2)			High	41(24.4)	
	Very high	49(29.2)			Very high	40(23.8)	
I am unhappy when I cannot get sufficient illumination to read	Lowest	14(8.3)	3.66	I am stressed when using the library	Lowest	55(32.7)	2.42
	Low	18(10.7)			Low	43(25.6)	
	Medium	34(20.2)			Medium	37(22)	
	High	47(28)			High	11(6.5)	
	Very high	55(32.7)			Very high	22(13.1)	
I am more energetic when in the library	Lowest	14(8.3)	3.46	The lighting conditions make me annoyed visually	Lowest	62(36.9)	2.42
	Low	31(18.5)			Low	34(20.2)	
	Medium	34(20.2)			Medium	28(16.7)	
	High	42(25)			High	27(16.1)	
	Very high	47(28)			Very high	17(10.1)	
I am inspired to study more when in the library	Lowest	7(4.2)	3.51	I suffer from eye fatigue when studying	Lowest	45(26.8)	2.58
	Low	26(15.5)			Low	38(22.6)	
	Medium	55(32.7)			Medium	39(23.2)	
	High	34(20.2)			High	34(20.2)	
	Very high	46(27.4)			Very high	12(7.1)	
My concentration is higher when using the library	Lowest	10(6)	3.55	I am distracted when using the library	Lowest	58(34.5)	2.35
	Low	26(15.5)			Low	36(21.4)	
	Medium	43(25.6)			Medium	40(23.8)	
	High	40(23.8)			High	25(14.9)	
	Very high	49(29.2)			Very high	9(5.4)	

This is consistent with global findings from writers such as Aram and Alibaba [18], who found that well-designed daylight improves mood and user well-being, whereas bad lighting reduces emotional state and perceived visual comfort. This means that library architects should prioritise integrating ample yet glare-free daylight sources, such as north-facing windows or light shelving, in order to sustain good emotional responses and avoid discontent in low-light situations. Energy and inspiration levels are both high, with a mean of 3.46 (53% high or highly energetic) and a mean of 3.51 (48% high or strongly inspired). This means that daylit library spaces promote alertness and motivation, supporting the relationship between daylight and increased cognitive vigour.

This research suggests that strategic daylight penetration—via skylights, clerestories, and reflective surfaces—should be prioritised to improve focus and academic drive. In terms of concentration and distraction, concentration had a mean of 3.55 (52.8% high or maximum), whilst distraction was low (mean = 2.35), with 56.9% indicating little distraction. This means that well-lit environments promote concentrated work while minimising distractions, reflecting findings linking natural light to decreased cognitive fatigue and increased attention span. This implies that libraries should be designed to prevent direct glare and overly bright hotspots. Implementing indirect lighting methods and zoning to provide continuous concentration throughout the space.

Relaxation has a mean of 3.36 (47.7% medium to high), whereas tension has a mean of 2.42. This suggests that daylit situations make people feel more comfortable and less worried. Daylight exposure has been found to help regulate circadian cycles and reduce stress. As a result, visual breaks in the form of views of greenery or outside vistas, as well as moderate indoor brightness, are required to comfort users emotionally. Overall, our data confirm that daylighting improves emotional well-being (happy, inspiration, reduced stress), boosts cognitive performance (energy, attention, fewer distractions), and is critical to the psychological and functional quality of educational library spaces.

4.4 Identify the Impact of Daylight on Health

The results in Table 4 show that the Visual Comfort Against Flicker & Over-Illumination has mixed reactions. 39.9% agree or strongly agree that visual comfort is adequate; 35.1% are neutral, and 25% disagree. The Mean is 3.17, showing a neutral position—neither clearly satisfied nor dissatisfied. This means that people do not significantly like or dislike the current lighting settings, which include flicker and over-illumination. This means that daylighting is adequate but may occasionally cause discomfort, most commonly owing to glare or stray bright spots. On the topic of discomfort caused by flickering or over-lighting, 26.7% agree or strongly agree. 34.5% are indifferent, and 38.7% disagree, with a mean of 2.79. This suggests that a sizable proportion of users are unconcerned about slight pain, while a sizable proportion (38.7%) are not bothered. This demonstrates some variance in sensitivity to flicker or brightness, indicating the need for improved glare reduction. In terms of Glare Perception, 28.5% indicate high glare, 29.8% are neutral, and 41.7% disagree. This means that while 41.7% do not perceive glare concerns, which is good, a significant minority (almost 30%) do. This illustrates that glare is still an issue in some areas. 51.2% agree/strongly agree that illumination improves safe movement. 26.8% are neutral, while 22.2% disagree. This means that more than half of participants are confidence in their ability to move about, implying that daylighting aids navigation. However, about one-fifth feel insecure, indicating the possibility of dim or uneven terrain. On Lighting in Circulation Spaces, 47% agree that daylight architecture improves light distribution in corridors and common areas. 32.7% are neutral, 20.3% disagree. This means that over half of users consider circulation spaces to be well-lit by daylight, while approximately 20% believe there is need for improvement, particularly where routes appear gloomy or patchy.

Based on these findings, the following implications for Library Daylighting Design can be drawn: (i) Balancing Brightness and Glare Control - The presence of neutral and negative reactions regarding comfort and glare indicates an unequal light quality. As indicated in the Whole Building Design Guide (WBDG), high brightness without regulation can cause glare and discomfort. The design focus must include dispersing strategies—such as light shelves, towering clerestories, and matte surfaces—to offer adequate light without glare or flickering. (ii) Improving Visual Comfort Uniformity - Neutral mean ratings for flicker and over-illumination emphasise the importance of even, controlled, flicker-free daylight. The design should prioritise the use of shading devices, glare sensors, and zoned lighting systems (daylight harvesting) to ensure constant, adaptive illumination based on occupancy and daylight availability.

Table 4. Impact of daylight on health

Variable	Level of agreement	Frequency (%)	Mean value
The visual comfort against flickering and over illumination in the library is comforting	Strongly disagree	16(9.5)	3.17
	Disagree	26(15.5)	
	Neutral	59(35.1)	
	Agree	47(28.0)	
	Strongly Agree	20(11.9)	
The visual comfort against flickering and over illumination in the library is discomforting	Strongly disagree	27(16.1)	2.787
	Disagree	38(22.6)	
	Neutral	58(34.5)	
	Agree	34(20.2)	
	Strongly Agree	11(6.5)	
The illumination within the library indoor environment is glaring into my eye	Strongly disagree	21(12.5)	2.815
	Disagree	49(29.2)	
	Neutral	50(29.8)	
	Agree	36(21.4)	
	Strongly Agree	12(7.1)	
The illumination level within the library helps/enhances safety of movement	Strongly disagree	19(11.3)	3.32
	Disagree	18(10.7)	
	Neutral	45(26.8)	
	Agree	62(36.9)	
	Strongly Agree	24(14.3)	
The design of the circulation spaces optimizes the distribution of light in the library	Strongly disagree	9(5.4)	3.3
	Disagree	25(14.9)	
	Neutral	55(32.7)	
	Agree	64(38.1)	
	Strongly Agree	15(8.9)	

The design should prioritise the use of shading devices, glare sensors, and zoned lighting systems (daylight harvesting) to ensure constant, adaptive illumination based on occupancy and daylight availability. (iii) Improving Safety and Circulation Lighting - With approximately 20-22% of respondents disagreeing on safety and corridor lighting, certain zones may lack appropriate brightness, resulting in low visibility difficulties. The design focus should be on using daylighting in corridors and moving areas, such as skylights or window strips, to maintain minimal illuminance levels and visual interest. (iv) Addressing Glare Hotspots – Nearly 30% of respondents reported glare, indicating that bright beams were striking work areas. The design should prioritise precise fenestration placement, the use of indirect illumination (e.g., clerestories), and the use of shading to prevent direct sunlight from reaching desktop surfaces. The overall design implications of these findings are that they correlate with best practices in daylighting: natural light must be controlled, uniform, glare-free, and adaptively managed to ensure both visual comfort and functional safety. For Nigerian university libraries, this entails creating daylighting that is user-centric, well-shaded, zoned, and meets basic safety standards, especially in corridors.

4.5. Visual Comfort in the Library and the Impact of Lighting Condition

To assess whether there is a relationship between users' visual comfort and the impact of lighting conditions in the library. Table 5 shows the findings of Chi-square and Kendall Tau-b analysis. Visual comfort and perceived lighting influence have a moderate positive connection (Kendall $\tau_b = 0.235$, $p < 0.05$). This underscores the idea that optimal daylighting solutions, particularly those that reduce glare, flicker, and uneven brightness, can significantly improve user happiness. However, visual comfort is only one aspect of the lighting experience; other elements such as daylight quantity, homogeneity, and environmental management are likely to be relevant and should be addressed in integrated design guidelines.

Table 5. Relationship between visual comfort and the impact of lighting conditions.

			Visual comfort	Impact of lighting condition
Kendal-tau-b	Visual comfort	Correlation Coefficient	1.000	.235**
		Sig. (2-tailed)	.	.000
		N	168	168
	Impact of lighting condition	Correlation Coefficient	.235**	1.000
		Sig. (2-tailed)	.000	.
		N	168	168

ANOVA (Analysis of variance) was used to see whether there is a significant difference in the impact of lighting on library users across the school. Table 6 displays the ANOVA results for the impact of lighting conditions.

Table 6. ANOVA analysis on impact of lighting condition

Impact of lighting condition in the library					
	Sum of Squares	Degree of freedom	Mean Square	F	Sig.
Between Groups	5.842	3	1.947	6.395	.000
Within Groups	49.943	164	.305		
Total	55.785	167			

Table indicates: (i) Between-group variability: SS = 5.842, df = 3. (ii) Within-group variability: SS = 49.943, degree of freedom (df) = 164 (iii) F-statistic = 6.395, p-value < 0.001. We reject the null hypothesis ($p < 0.05$) and find that there are substantial differences in how users perceive lighting impact across four schools. This means that the effects of lighting conditions on library users across the school are not uniform; they vary by school. Figure 1 depicts the mean graph indicated in red color of the lighting conditions in the libraries across the schools. According to its Statistical Significance, the F-value of 6.395 suggests that differences in mean evaluations among institutions are unlikely to be random, confirming genuine variance in lighting circumstances and/or perceptions. The practical relevance emphasises that variations in perceived illumination quality may be due to site-specific architectural variables, such as window design, shading, orientation, or daylight control systems. The design implications for daylighting optimisation imply the necessity for (1) tailored daylighting interventions. Because of the wide range of lighting impacts, a "one-size-fits-all" daylighting strategy will fail.

Each library demands context-specific solutions that consider its unique architectural elements and daylight dynamics. (2) Benchmark High-Performing Schools: Determine which institution has the highest mean rating. Use its daylighting design (fenestration arrangement, glazing type, shading devices, interior finishes) as a best-practice example for others. (3) Target Underperforming Libraries - Schools with lower ratings are more likely to experience challenges such as insufficient sunshine penetration, glare, or a lack of control. Optimise via specific treatments such as (i) improving window orientation, adding clerestories, or skylights. (ii) Install shading systems (such as louvres and light shelves), and (iii) use higher-reflectance interior finishes to improve daylight distribution. (4) Implement Data-Driven Design - Repeat daylight simulations with occupant feedback to identify deficiencies and confirm solutions per school.

ANOVA was used to measure the visual comfort of daylight in the library among four institutions. Table 7 shows the results of an ANOVA analysis of visual comfort in the library. The results reveal (i) between-groups SS = 0.585 (df = 3) and within-groups SS = 65.746 (df = 164). (ii) The F-value is 0.486, p = 0.692, which is greater than 0.05. It may be concluded that there is no statistically significant difference in visual comfort scores between the four schools. The following might be seen from the results. (i) Consistent Visual Comfort - The lack of significant variance ($p > 0.05$) indicates that users in all libraries experience similar levels of daylight-related visual comfort, regardless of physical or contextual differences between schools.

Table 7. ANOVA Analysis of Visual comfort.

Visual comfort at the library	ANOVA				
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.585	3	.195	.486	.692
Within Groups	65.746	164	.401		
Total	66.331	167			

(ii) Daylighting tactics Are Comparable - Despite architectural or regional variances, each library appears to use daylighting tactics that result in similar comfortable visual circumstances. (iii) Comparison with Lighting influence - Previous research found disparities in the perceived influence of lighting between schools. However, these do not transfer into variances in basic visual comfort, indicating that ambiance or perceived productivity varies more than core comfort. Figure 1 shows a graph of the mean across the schools indicated in blue color of the visual comfort of daylight.

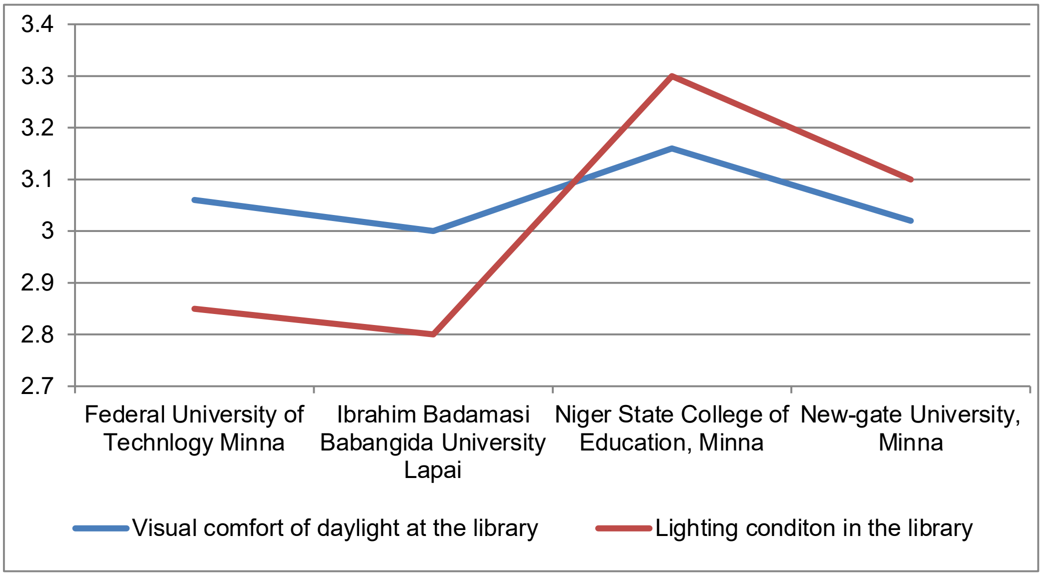

Figure 1. Mean graph of impact of lighting conditions and visual comfort

5. CONCLUSIONS

This study addresses the issue of many Nigerian university libraries relying significantly on artificial lighting due to poor architectural design, resulting in higher energy costs and worse visual comfort. It looked into how spatial orientation, window design, daylight control technologies, and material choices may improve daylighting in university libraries. Based on the research findings, many significant conclusions are derived that are consistent with the goal of optimising daylighting in Nigerian university libraries. First, it is possible to determine that daylighting quality is generally adequate. This is mirrored in users' positive ratings of natural light provision and illumination uniformity, indicating that existing daylighting solutions meet basic comfort criteria. Second, sunshine promotes well-being and productivity, as seen by high scores for happiness, energy, attention, and inspiration, as well as lower stress and distraction, demonstrating substantial positive correlations between daylight and cognitive/emotional advantages in library users. Third, health and safety are mixed, with neutral answers to flicker, glare, and over-illumination, and worries about circulation lighting highlighting opportunities for improvement. Fourth, visual comfort partially predicts positive perception, as the results reveal a moderate, significant association, confirming that improving glare-free, consistent visual comfort improves overall impressions of lighting quality. Fifth, there are institutional differences, as the ANOVA results show substantial changes in perceived lighting impact between institutions, but no significant variance in visual comfort. This shows that basic comfort is stable, while other factors such as ambiance and functional performance differ between school. Finally, this study supports a multidimensional optimisation strategy that includes preserving existing daylight comfort while improving functional, emotional, and safety aspects through tailored, user-centred daylight design—particularly glare control, spatial uniformity, and targeted institutional interventions. This approach is consistent with the best practices for high-performance daylighting promoted by WBDG.

6. RECOMMENDATIONS

The guidelines below are made to optimise daylighting strategies in Nigerian educational learning environments. (i) Prioritise glare control and visual comfort by using exterior/integrated shading devices such as light shelves, overhangs, and louvres to deflect direct sunlight and reduce glare. The use of light shelves is particularly essential as they can prevent glare and allow natural light to penetrate deeper into the space through indirect lighting. This approach is particularly effective for the "soft component" of daylight and is especially suitable for libraries. Choose glass with moderate-to-low solar heat gain coefficients and good visual transmittance; use low-emissivity coatings to reduce glare and thermal gain (ii) Improve Uniformity and Flicker-Free Lighting. To softly diffuse daylight, increase interior reflectance by >80% on ceilings, >50% on walls, and ~20% on floors. Also Use lowering daylight-responsive electric lighting and day-light harvesting controllers to keep illumination levels consistent throughout the day. (iii) Improve Circulation Space Safety - In corridors, supplement glass with skylights or high clerestories to meet minimum illuminance requirements and facilitate navigating. Use zonal daylight control to avoid dark areas while maintaining overall daylight harmony. (iv) Customise Solutions for Each Institution - Use post-occupancy evaluations and post-hoc lighting studies to determine which libraries have a low perceived lighting influence. Implement library-specific interventions, such as adding light shelves or shade to deep layouts and increasing windows in low-light zones. (v) Establish Daylighting Benchmarks - Based on the best-performing institutions, develop site-appropriate criteria (for example, daylight autonomy and illuminance range). Use simulation tools (radiance, climate-based modelling) early in the design process to test shading, glazing, and orientation techniques. (vi) Implement User-Controlled Shading and Smart Glazing by installing adjustable blinds (e.g., bidirectional) and smart glass (electrochromic) to enable occupants to modify daylight based on task and preference. (vii) Conduct regular evaluations - Implement continuous monitoring and feedback loops to adjust daylight system performance after occupancy. Track parameters such as user happiness, illuminance, glare indices, and energy savings to ensure continued optimisation.

REFERENCES

[1] Flynn, J. E., Spencer, T. J., Martyniuk, O., & Hendrick, C. (1973). **Interim study of procedures for investigating the effect of light on impression and behavior**. *Journal of the Illuminating Engineering Society*, 3(1), 87-94.

[2] Rahman, F., & Tuhin, M. M. H. (2019). **Daylight impact on learning environment in classrooms of secondary high school at Ishwardi, Pabna, Bangladesh**. *International Research Journal of Engineering and Technology* (IRJET). Volume: 06 Issue: 10., 1148 – 1153.

[3] Liu, B., Liu, Y., Deng, Q., & Hu, K. (2023). **A study on daylighting metrics related to the subjective evaluation of daylight and visual comfort of students in China**. *Energy and Buildings*, 287, 113001.

[4] Edwards, L. & Torcellini, P. (2002). **A Literature Review of the Effects of Natural Light on Building Occupants**. National Renewable Energy Lab (NREL).

[5] Li, D. H. W., & Tsang, C. L. (2008). **An analysis of daylighting performance for office buildings in Hong Kong**. *Building and Environment,* 43(9), 1446–1458. https://doi.org/10.1016/j.buildenv.2007.08.002

[6] Samani, S. A., Samani, S. A., & Parasteh, M. (2013). **A review paper of: the impact of daylight on students" learning performance**. *Journal of Management and Science,* 3(1), 62-68.
[7] Mohamedali, A. (2017). **A Methodology for Daylighting Optimisation in Academic Libraries: Case Study of EMU Main Library** (*Master's thesis*, Eastern Mediterranean University EMU-Doğu Akdeniz Üniversitesi (DAÜ)).
[8] Ibhadode, O., Ajayi, O. O., Abioye, A. A., Ismaila, J., & Adekunle, A. A. (2019). **An evaluation of classroom-illumination: a critical requirement for effective designing and construction of naturally-illuminated schools in Nigeria**. *Progress in Industrial Ecology, an International Journal,* 13(4), 342-372.
[9] Ukpong, E., Uzuegbunam, F. O., Ibem, E. O., & Udomiaye, E. (2025). **Daylighting performance evaluation in tropical lecture rooms: A comparative analysis of static and climate-based metrics**. *Journal of Building Engineering*, 112044.
[10] Timothy, T. D., El-Nafaty, A. S. I., Umar, A., Bashir, U. M., Abubakar, S. K., & Wakawa, U. B. (2024). **Daylight Optimization in Reading Spaces in the Design of Architecture Library, Kaduna State University, Nigeria**. *African Journal of Environmental Sciences and Renewable Energy,* 17(1), 113-120.
[11] Adewale, B., Jegede, F., Okubote, F., & Olagbadegun, M. (2021, March). **Impact of classroom environments' on the academic performance of architecture students in Covenant University**. In *IOP conference series: Earth and environmental science* (Vol. 665, No. 1, p. 012017). IOP Publishing.
[12] Mortazaee, S., & Haron, S. H. (2021). **A Review of Daylight Impacts on Luminous Comfort in Libraries**. *In Advances in Civil Engineering Materials: Selected Articles from the International Conference on Architecture and Civil Engineering (ICACE2020)* (pp. 1-10). Springer Singapore.
[13] Creswell, J. W., & Creswell, J. D. (2017). **Research design: Qualitative, quantitative, and mixed methods approaches**. Sage publications.
[14] Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). **Comparison of Convenience Sampling and Purposive Sampling**. *American Journal of Theoretical and Applied Statistics,* 5(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11
[15] Kotrlik, J. W. K. J. W., & Higgins, C. C. H. C. C. (2001). **Organizational research: Determining appropriate sample size in survey research appropriate sample size in survey research**. *Information technology, learning, and performance journal,* 19(1), 43.
[16] Boyce, P. R. (2003). **Human factors in lighting**. *Crc press*.
[17] Akande, O. K., Olagunju, R. E., Aremu, S. C., & Ogundepo, E. A. (2018). **Exploring factors influencing of project management success in public building projects in Nigeria***. jbe,* 0004.
[18] Aram, R., & Alibaba, H. Z. (2018). **Investigation of the effects of daylight in a university Library**. *Journal of Architectural and Planning Research*, 35(4), 343-356.