Available online www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 210 (2025) 82-92 EISSN 2392-2192

# Students' Perception of the Spatial Distribution of Lecture Halls and Its Implications in the University of Calabar, Nigeria

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**ABSTRACT**

University campus academic facilities layout is an important but usually ignored variable determining the academic environment. This study investigated undergraduate on-campus students' perception of the locations of the University of Calabar's lecture halls and the academic implications. A descriptive study entailed the administration of a closed-ended questionnaire to 318 on-campus undergraduate students. Using the Yamane formula, sample size was calculated, and random sampling used to distribute the questionnaire. The response data collected included various elements, such as participants' demographics, their distance perceptions to the lecture rooms, their transportation modes, economic consequences of their transportation, as well as their concerns regarding the level of noises around the lecture areas. Statistical analysis, in the case of study, was carried out by the use of ANOVA in order to evaluate the differences in the perceived distance between the lecture venues and the students' residential areas, while Chi-Square tests were carried out in order to examine the connection between the lecture rooms' sites and students' academic performance. The results indicated that there was a highly significant difference in the distance to the lecture by various sites of the hostel, with the statistical findings indicating ($F(5, 312) = 5.476$, $p < .05$), reflecting an uneven distribution in the distance. In addition, a remarkable 77% of the participants showed that the current location of the lecture rooms has an adverse impact both in their academic performance and in their punctuality, an aspect that was supported by the Chi-Square test findings ($\chi^2(1) = 93.031$, $p < .001$).

(Received 10 October 2025; Accepted 18 November 2025; Date of Publication 9 December 2025)

The elements that were the main source of concern for the participants were the long distance they have to walk in order to attend the lecture rooms, the economic consequences related to the transportation fees, as well as high noises around the lecture areas, resulting from the traffic (44.4%) and commercial activity (35.2%). The study finds that the layout of lecture halls at the University of Calabar violates optimal service distribution and negatively affects students' academic experience. It calls for a reevaluation of campus planning to enhance accessibility and reduce environmental issues.

***Keywords:*** Campus Planning, Spatial Distribution, Student Perception, Lecture Halls, Accessibility, ANOVA, Chi-Square, University of Calabar, Nigeria.

## 1. INTRODUCTION

### 1.1. Background and Literature Review

University campus is an integrative spatial system that pursues the tripartite mission of learning, research, and civic engagement. Within the system, the organization of academic spaces, especially the lecture rooms, is critical to the formation of the daily life and academic performance of learners (Chapman & Sack, 2014). How the learners walk between where they live (hostels) and where they study (lecture theaters) transcends logistically necessary considerations and becomes an critical determinant shaping academic engagement, on-time arrival to places of academic work, and well-being more generally (Timmermans & van der Heijden, 1996). Retaining key facilities within an accessible and secure walking distance range by users has come to be increasingly identified as an integral component of sustainable university campuses and student-centered architecture and building design (Balsas, 2016).

The theoretical bases of this research are rooted in Central Place Theory (Christaller, 1933) and the wider debate on spatial accessibility. Central Place Theory, originally developed to explain the distribution of urban centers, can also be transferred to an academic campus environment, where classrooms represent higher-order services that should be centrally and fairly located to effectively serve the student body (Ogu, 2017). A pattern following this rule reduces the friction of distance and hence provides balanced accessibility to all the students, regardless of the locations of the hostels they stay in (Hansen, 2007). Where the pattern gets distorted, the distortion begets spatial inequities that disproportionately affect the students staying in the outer-zone hostels (Owoeye & Omole, 2012).

Empirical evidence has continued to demonstrate a link between the distance students travel to learning institutions and the academic performance. Long commutes have been linked to increased stress and fatigue and the decreasing availability of time to study and take part in extracurricular activities, thus negatively influencing academic performance (Cheng, 2016). With the consideration of the Nigerian university campuses facing challenges related to fast growth and lack of infrastructural planning, the problem is particularly salient (Fabiyi & Ogunyemi, 2015). Research by Ojo et al. (2017) on the University of Lagos showed that the students who took long to travel to their lectures reported increased tardiness and lower attendance rates. Similarly, Olatunji and Ajayi's research (2018) highlighted the fact that inefficiently designed campuses and long distances between the buildings heightened the fatigability among students and reduced concentration levels among the students during lectures.

Aside from distance considerations, environmental quality in the form of acoustic conditions is also a determining factor. Noise pollution is a significant environmental stress that has adverse effects on cognitive processes, including memory, attention, and information processing (Klatte, Bergström, & Lachmann, 2013).

Lecture auditoriums along busy roadsides or business areas tend to be exposed to high noise levels, to the disadvantage of the teaching-learning process, dampening the lecturer's voice and decreasing learners' efficacy to hear and retain information (Shield & Dockrell, 2008). Astolfi and Filippi's research (2003) is supportive of the fact that improper acoustics within the university teaching spaces is an international phenomenon causing dissatisfaction among students and inhibiting academic performance.

Despite the fact that previous research has looked at the environmental considerations and the campus planning separately, it is time to conduct holistic research by interlinking the spatial location of the facilities with the environmental quality around them and the resulting perceptual and academic effects on the users.

This research tries to make up for the gap by conducting the whole analysis on the perception by the main users—the students—of the spatial positioning of the lecture halls at the University of Calabar and how the perception is connected to tangible academic challenges.

### 1.2. Novelty and Objectives

Prior research on the Nigerian university system has generally dealt with sweeping questions of infrastructure deterioration, finance, or leadership and has not dealt specifically with the micro-geography of the campus and its immediate effect on the student body. This research is innovative by virtue of its holistic methodology, intertwining spatial analysis (variety of distances), perceptual survey (students' perception), and statistical verification (ANOVA and Chi-Square tests) to yield an empirical, student-focused analysis of the distribution of campus facilities. This proceeding advances beyond the anecdotal to statistically confirm hypotheses on the issue of spatial fairness and academic consequence within the distinct frame of the University of Calabar. The primary objectives of the study is to:

- To assess students' perceptions of the proximity and accessibility of lecture halls from their respective hostels at the University of Calabar.
- To analyze the variation in perceived distance to lecture halls across the different undergraduate hostels on campus.
- To evaluate the environmental challenges, particularly noise pollution, associated with the current locations of the lecture halls.
- To determine the perceived implications of lecture hall locations on students' academic performance and punctuality.

## 2. MATERIALS AND METHODOLOGIES

### 2.1. Study Area Description

The University of Calabar (UNICAL) is a federal institution situated in Calabar, which serves as the capital of Cross River State, Nigeria. Since its inception in 1975, the university has experienced considerable expansion in terms of both student enrollment and physical facilities. The primary campus exhibits a complex arrangement that includes academic departments, administrative offices, student accommodation, and various other support services distributed over an extensive area. Lecture halls are primarily organized within designated zones, whereas the undergraduate accommodations, identified as Halls 2, 4, 5, 6, 8, and 9, are located in diverse sections of the campus, resulting in differing travel distances and pathways for students. This spatial disconnection between living and academic areas constitutes the principal issue explored in this research.

### 2.2. Data Sources and Preparation

The study adopted mixed-methods research to acquire data by involving primary and secondary data sources.

#### 2.2.1. Primary Data

Primary data were directly collected through a structured questionnaire survey conducted on the intended population. The questionnaire design sought to collect nominal data, which is especially efficient to sort responses without the implication of any quantitative value (Salkind, 2017). Demographic information (gender, status, faculty), perception about the distance to the lecture hall, cost of transportation, transportation modes, perception about noise, noise sources, and the effect on academic performance and punctuality due to the location of the lectures hall were the measured parameters. Finally, field observations also took place to cross-validate the data on distances and environmental parameters that were self-reported.

#### 2.2.2. Secondary Data

Data used here were obtained from the Students Affairs Division of the University of Calabar that listed the total population to be 2,500 undergraduate students staying within the six hostels on the university's campus. This data formed the basis on which the sampling frame could be developed. Also, an outline map of the university was sourced through Google Earth to provide a spatial structure to the layout of facilities.

### 2.3. Methodology

#### 2.3.1. Research Design

The descriptive research study was the research design used in the current study. This research design is deemed appropriate since it ensures proper depiction of the characteristics of a particular individual, situation, or aggregation (Creswell & Creswell, 2018). Under this structure, it has been used to systemically describe the perception, experience, and attitude of University of Calabar students regarding the location of their lecture rooms. The closed questionnaire acted as an accurate and consistent instrument to ascertain this descriptive data.

#### 2.3.2. Population and Sampling

The study's population of concern included the entire 2,500 undergraduate residents within the six residential hostels within the University of Calabar. Calculating the sample size was conducted using the Yamane (1967) formula for finite populations, which is quite simple and focuses on obtaining a 95% confidence level with an error margin (e) of 0.05.

The equation is presented as follows:

$$n = \frac{N}{1+N(e)2}$$

Where: N = Populations

1+N (e) 2 = tolerable error (at 0.05)

And this was calculated as

$$n = \frac{2500}{1+2500(0.05)2} = 345$$

One quick calculation provided an initial sample size of 345. However, only 318 of the questionnaire was retrieved successfully, the final sample size of 318 was adopted and randomly administered to each of the six hostel halls through the distribution of 53 questionnaires. With this simple random sampling technique that falls under the category of probability sampling, each student staying within the hostels got an equal chance to be selected and therefore enhanced the representativeness of the sample (Taherdoost, 2016).

### 2.3.3. Data Collection and Analysis

A total of 318 questionnaires were retrieved across the six hostels. Obtained data were analyzed using the Statistical Package for the Social Sciences (SPSS version 25). Descriptive statistical procedures involving frequencies, percentages, and means were used to summarize the demographic and perceptual data.

To examine the hypotheses, inferential statistical methods were utilized:

Hypothesis 1 (Variation in Distance): This was tested through a one-way Analysis of Variance (ANOVA) test. ANOVA is a strong statistical method employed to ascertain whether there exists any statistically significant difference between the means of three or more independent groups (Field, 2018). Here, the independent variable was the Hostel Hall (with 6 groups), and the dependent variable the perceived distance to the lecture halls. This null hypothesis ($H_0$) was rejected if the p-value (Sig.) was below the chosen significance level of 0.05. The formula is F = MST / MSE, where MST is the mean sum of squares due to the treatment and MSE is the mean sum of squares due to error.

Hypothesis 2 (Negative Implication on Academics): The investigation was conducted utilizing the Chi-Square ($\chi^2$) test of independence. This test is categorized as a non-parametric statistical method employed to ascertain whether a significant relationship exists between two categorical variables (McHugh, 2013). In this context, it was applied to examine the correlation between the location of lecture halls—indicated by the students' affirmative or negative responses regarding its adverse effects—and the posited detrimental influence on academic achievement. The null hypothesis ($H_0$), which states that no association exists, was deemed rejected if the asymptotic significance (p-value) fell below the threshold of 0.05. The formula is

$$X^2 = \sum \frac{(Oi-Ei)}{Ei}$$

Where: ∑=Summation

Where Oi is the observed frequency and Ei is the expected frequency.

## 3. RESULTS

These are the results generated through data analysis listed here starting with the demography of the respondents and then the descriptive and inferential results that touch on the study's major objectives.

### 3.1. Understanding Proximity and Accessibility

One core finding from the research pertains to students' perception regarding the distance between their lecture venues. Table 1 reveals that only an insignificant percentage rated the distance between the lecture venues to be "very near" (2.8%) and "near" (19.2%). Most of them totaling 41.2% rated the distance as "optimum," and an appreciable distance totaling 33% rated it as "far," and 3.8% rated it as "very far." This suggests that more than a third of the student respondents (36.8%) rate the distance as being the key barrier.

**Table 1.** Proximity to lecture halls.

| | Frequency | Percent |
|---|---|---|
| very near(<10min) | 9 | 2.8 |
| Near(10-15min) | 61 | 19.2 |
| optimum distance(16-24min) | 131 | 41.2 |
| Far(25-30min) | 105 | 33 |
| very far (>30min) | 12 | 3.8 |
| Total | 318 | 100 |

This perception is closely related to their transportation choices and related costs. As listed in Table 2, walking is the leading transportation mode used by students, representing 73.3% of the sample, thus highlighting the imperative of walkable distances. A smaller group uses the school shuttle bus, representing 22%, or automobiles and other cars and bikes on hire representing 4.7%. Figure 8 depicts a financial implication among part of the population since 31.4% of respondents reported paying a cost (consisting of N30 and more) to get to their lecture venues. This finding is remarkable considering it highlights an indirect cost burden faced by students due to the spatial distribution pattern of the amenities within the university's campuses. For that reason, as shown in Table 4.7, a significant proportion of 60.7% respondents spoke to the preference to see the lecture venues closer to student residential areas, signaling the prevailing dissatisfaction with the layout.

**Table 2.** Means of transportation to Lecture Halls.

| | | Frequency | Percent | |
|---|---|---|---|---|
| Walking | 233 | 73.3 | | 73.3 |
| private vehicles | 15 | 4.7 | | 4.7 |
| School shuttle | 70 | 22 | | 22 |
| Total | 318 | 100 | | 100 |

### 3.3. Environmental Issues: Noise Pollution

The environmental quality inside the lecture halls has also become a concern. Based on the information described in Table 4.8, more than half the participants (53.5%) reported having noise disturbances inside their lecture halls. Further examination on the causes of this noise disturbance (Table 3) identified passing vehicles to be the most common cause (44.4%), followed by commercial operations (35.2%) and other unnamed university-associated operations (20.4%). This suggests that many lecture halls are situated inside acoustically sensitive areas, and this can compromise the learning environment.

**Table 3.** Noise in Lecture Halls.

| | Frequency | Percent |
|---|---|---|
| Yes | 170 | 53.5 |
| No | 148 | 46.5 |
| Total | 318 | 100 |

### 3.4. Hypothesis Testing

#### 3.4.1. Hypothesis 1: Variation by Proximity to Lecture

A one-way ANOVA was performed to evaluate the hypothesis that no significant differences exist in the distance to lecture halls from the different hostels. The findings, displayed in Table 4, indicate a statistically significant variation in perceived distance among the six hostels: $F(5, 312) = 5.476$, $p = .000$. Given that the p-value is below the alpha threshold of 0.05, the null hypothesis ($H_0$) is thus rejected. Consequently, this results in the acceptance of the alternative hypothesis ($H_1$), substantiating that a significant difference exists in the distance to lecture halls from the various hostels at the University of Calabar. This outcome offers empirical support for the spatial inequity regarding facility access, where students residing in certain hostels face systematic disadvantages due to longer travel distances compared to their counterparts in other hostels.

**Table 4.** Results of ANOVA.

| | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 19.535 | 5 | 3.907 | 5.476 | 0 |
| Within Groups | 222.604 | 312 | 0.713 | | |
| Total | 242.138 | 317 | | | |

### 3.4.2. Hypothesis 2: Adverse Effects on Scholarly Achievement

The Chi-Square test was employed to assess the correlation between the location of lecture halls and student academic performance. This statistical procedure involved comparing the actual frequencies of 'Yes' and 'No' responses regarding negative implications against the anticipated frequencies under the null hypothesis, which posits no relationship exists. The outcomes are pronounced. As demonstrated in Table 5, the actual count for 'Yes' (245) significantly surpassed the expected count (159), yielding a Chi-Square statistic of $\chi^2(1) = 93.031$, with an asymptotic significance of $p = .000$. Given that $p < 0.001$, substantially below the 0.05 significance level, the null hypothesis ($H_0$) is decisively rejected. This presents robust statistical evidence in favor of the alternative hypothesis ($H_1$), indicating that the locations of lecture halls at the University of Calabar negatively affect students' academic performance, according to the students' perceptions. This finding is consistent with the descriptive data, where 77% of respondents acknowledged this adverse impact (Table 5).

**Table 5.** Result of Chi-square.

| | Observed N | Expected N | Residual |
|---|---|---|---|
| Yes | 245 | 159 | 86 |
| No | 73 | 159 | -86 |
| Total | 318 | | |

## 4. DISCUSSION AND CONCLUSION

### 4.1. Analysis of Results

The results of the present investigation elucidate the difficulties linked to the spatial arrangement of lecture halls at the University of Calabar. The substantial discrepancies in distance from various hostels, as corroborated by the ANOVA analysis, signify a deficiency in centralized and equitable planning. This outcome directly contradicts the tenets of Central Place Theory (Christaller, 1933), which promotes a systematic allocation of services in relation to the population that requires them. The inequitable distribution engenders a situation of "spatial injustice" on campus, wherein a student's residential location becomes a critical factor influencing the effort and time necessary to access vital academic services (Soja, 2010). This phenomenon corresponds with the gravity model of spatial interaction, which asserts that the interaction between two locations diminishes as the expense of travel (specifically, time and energy) escalates (Wilson, 1971). Consequently, as highlighted by Fabiyi and Ogunyemi (2015), extended distances result in limited educational access, whereby only the most dedicated students persistently confront the associated difficulties.

The dismissal of the second null hypothesis, along with the significant student sentiment (77%) regarding adverse academic effects, highlights a vital correlation between the physical educational environment and academic performance.

The observation that a majority of students commute on foot to lectures indicates that extended distances consume both time and energy, which could have been allocated to studying or recuperation; this subsequently results in fatigue and diminished concentration during class—elements recognized as detrimental to cognitive function (Zhou & Wang, 2016). Additionally, the existence of noise pollution within lecture halls, predominantly stemming from vehicular traffic and commercial operations, intensifies the issue. Comprehensive studies in the field of environmental psychology have established that noise serves as a cognitive stressor, hindering speech clarity, memory retention, and focus (Klatte et al., 2013; Shield & Dockrell, 2008). Consequently, the positioning of lecture halls in areas susceptible to noise presents a dual disadvantage for students: they arrive fatigued due to a lengthy walk and are then exposed to a learning environment that does not facilitate effective knowledge acquisition.

The request by 60.7% of the respondents to relocate the venues of the lecture halls nearer to the student dorms is also a strong suggestion to the university management to reconsider its own university-wide master plan. Our research illustrates that the concern is more than merely about convenience and is also an issue about academic fairness and environmental psychology. The maintenance of the status quo may be inducing unwarranted academic distress and possibly damaging the group academic output of the entire student body.

### 4.2. Conclusion

Therefore, the study has successfully provided an empirical analysis directed at students on the spatial organization of the university's lecture halls. The results lead to three key conclusions: There is statistically significant difference on the accessibility to the spaces where lectures take place, where the students staying on particular hostels face disproportionately higher distances to travel than others. The current location of many of the lecture halls places them at risk of significant environmental noise pollution due to transportation and business activity, thus reducing the overall quality of the learning environment. The simultaneous effect of long distances to travel and suboptimal acoustic settings is observed by most students to have a physical detrimental impact on performance and timeliness during lectures. Therefore, there is a need for an urgent and strategic review of the spatial layout of the University of Calabar campus, specifically the relationship between where the students stay and where lectures take place. The outcome calls upon the management to adopt more sustainable and student-centered planning strategies that facilitate the academic mission of the university, not hinder it.

### 4.3. Recommendations

As the research results indicate, the following recommendations are made: The University of Calabar should also undertake an intensive spatial analysis on the campus to scientifically map and quantify the travel distances and times from all the student accommodations to all the main lectures venues. Future construction plans for educational institutions should favor sites that reduce the mean travel distance from locations where the students will be residing, in accordance with Central Place Theory principles. For the already existing lecture venues within noisy vicinity zones, the university ought to invest in sound mitigation techniques, including the placement of double-glazed windows, sound-absorbing panels, and control of commercial operations within immediate environs. Coverage and effectiveness of the school shuttle service must be increased and potentially subsidized to alleviate the transportation cost from the residents at the farthest stay-in hostels. Student voice and experience needs to be institutionalized to the planning and development committee's deliberative process on campus to make the future infrastructure projects user-informed.

**Statements and Declarations**

**Funding**

*"The authors declare that no funds, grants, or other support were received during the preparation of this manuscript."*

**Competing Interests**

*"The authors have no relevant financial or non-financial interests to disclose."*

**Author Contributions**

*All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by* ***David Mkpanam Nyong*** *and Adaobi Thelma Onyemaobi. The first draft of the manuscript was written by* ***David Mkpanam Nyong,*** *and co-author commented on previous versions of the manuscript. All authors read and approved the final manuscript."*

**Declarations**

Ethics approval**: "***Not applicable."*

Consent to participate**: "***Not applicable."*

Consent for publication**: "***Not applicable."*

**Availability of data and materials**

*"All data for this study were gotten from authors fieldwork"*

## References

[1] Astolfi, A., & Filippi, M. (2003). Good acoustical quality in restaurants: A compromise between speech intelligibility and privacy. *Acta Acustica united with Acustica, 89*(1), 11–17.

[2] Balsas, C. J. L. (2003). Sustainable transportation planning on college campuses. *Transport Policy, 10*(1), 35–49. https://doi.org/10.1016/S0967-070X(02)00028-8

[3] Chapman, M. P., & Sack, D. (2014). The campus as a learning environment: Planning for resilience and sustainability. *Planning for Higher Education, 42*(3), 1–12.

[4] Cheng, J. (2025). The impact of commuting time on students' academic performance: Evidence from nearby enrollment policy in China. *Journal of Regional Science.* https://doi.org/10.1111/jors.70015

[5] Christaller, W. (1933). *Die zentralen Orte in Süddeutschland [Central Places in Southern Germany]*. Prentice-Hall.

[6] Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and mixed methods approaches* (5th ed.). Sage Publications.

[7] Fabiyi, O. O., & Ogunyemi, S. (2015). Spatial distribution and accessibility to post-primary educational institutions in Ogun State, Southwestern Nigeria: Case study of Yewa South Local Government Area, Nigeria. *Journal of Scientific Research and Reports, 5*(6), 542–552. https://doi.org/10.9734/JSRR/2015/12328

[8] Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). Sage Publications.

[9] Hansen, W. G. (2007). How accessibility shapes land use. *Journal of the American Institute of Planners, 25*(2), 73–76. https://doi.org/10.1080/01944365908978307

[10] Klatte, M., Bergström, K., & Lachmann, T. (2013). Does noise affect learning? A short review on noise effects on cognitive performance in children. *Frontiers in Psychology, 4*, 578. https://doi.org/10.3389/fpsyg.2013.00578

[11] McHugh, M. L. (2013). The chi-square test of independence. *Biochemia Medica, 23*(2), 143–149. https://doi.org/10.11613/BM.2013.018

[12] Ogu, V. I. (2017). *Urban and regional planning theories and applications.* University of Lagos Press.

[13] Ojo, T., Amoaako-Sakyi, R., & Agyeman, W. (2015). Students' satisfaction of campus shuttling services: A Qualbus approach. *Management Research and Practice.*

[14] Olatunji, S. O., & Ajayi, O. D. (2018). Impact of campus layout on students' quality of life: A case study of Federal University of Technology, Akure. *Covenant Journal of Research in the Built Environment, 6*(1), 1–18.

[15] Oppewal, H., & Timmermans, H. J. P. (1999). Modeling consumer perception of public space in shopping centers. *Environment and Behavior, 31*(1), 45–65. https://doi.org/10.1177/00139169921971994

[16] Owoeye, J. O., & Omole, F. K. (2012). Built environment decay and health situation of slum dwellers in residential cores of Akure, Nigeria. *American Journal of Human Ecology, 1*(2), 33–39.

[17] Salkind, N. J. (2017). *Exploring research* (9th ed.). Pearson.

[18] Shield, B., & Dockrell, J. E. (2008). The effects of environmental and classroom noise on the academic attainments of primary school children. *The Journal of the Acoustical Society of America, 123*(1), 133–144. https://doi.org/10.1121/1.2812596

[19] Soja, E. W. (2010). *Seeking spatial justice.* University of Minnesota Press. https://doi.org/10.5749/minnesota/9780816666676.001.0001

[20] Taherdoost, H. (2016). Sampling methods in research methodology: How to choose a sampling technique for research. *International Journal of Academic Research in Management, 5*(2), 18–27. https://doi.org/10.2139/ssrn.3205035

[21] Wilson, A. G. (1971). A family of spatial interaction models, and associated developments. *Environment and Planning A, 3*(1), 1–32. https://doi.org/10.1068/a030001