International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 07 | July 2024 www.irjet.net p-ISSN: 2395-0072

Indoor Environmental Quality Assessment of an Educational Building

Yash Singh[1], Anuj Kamal[2], Ashish Gaur[3], Rohit Rai[4], Mukul Saxena[5]

[1]B.Tech Student, Dept. of Civil Engineering, Rajkiya Engineering College, Kannauj, 209732, Uttar Pradesh, India
[2]B.Tech Student, Dept. of Civil Engineering, Rajkiya Engineering College, Kannauj, 209732, Uttar Pradesh, India
[3]B.Tech Student, Dept. of Civil Engineering, Rajkiya Engineering College, Kannauj, 209732, Uttar Pradesh, India
[4]B.Tech Student, Dept. of Civil Engineering, Rajkiya Engineering College, Kannauj, 209732, Uttar Pradesh, India
[5]Assistant Professor, Dept. of Civil Engineering, Rajkiya Engineering College, Kannauj, 209732, Uttar Pradesh, India

---

Abstract - *This paper examines the correlation between Rajkiya Engineering College, Kannauj, Uttar Pradesh, India's indoor environmental quality (IEQ) and student outcomes, such as perceived learning, course satisfaction, and IEQ satisfaction. Descriptive statistics analysis has used to examine the data that was gathered from 157 students throughout the course of four floors at various times. The findings display a significant impact on scholar results from IEQ, which includes thermal conditions, indoor air quality, acoustic situations, lighting conditions, furnishings, aesthetics, era, and look at conditions. The IEQs of different employees businesses and zones did, however, various drastically. Common troubles covered loudness, cramped quarters, uncomfortable temperature sensations, and terrible indoor air best. The properly-being, comfort, and productiveness of occupants rely closely on IEQ, and information it can assist discover regions in which building parameters need to be stepped forward. The results indicated that favourable pupil results were linked to the IEQ of the lecture rooms, which covered such things as temperature, indoor air fine, acoustic conditions, lighting conditions, furnishings, aesthetics, technology, and view conditions. The paper analyses the factors affecting the IEQ for students inside the lectures/classrooms of educational building of Rajkiya Engineering College, Kannauj, Uttar Pradesh, India during different time period.*

Key Words: *IEQ, Educational buildings, Acoustic comfort, IAQ, Visual comfort, Thermal comfort*

1.INTRODUCTION

Humans spend 90–95% of their time indoors, and a minimum of 30% of nonindustrial buildings are thought to be problematic buildings, with indoor air pollution being a major contributing factor. The health and academic performance of children greatly depend on the indoor air quality in school classrooms being characterized. Numerous indoor pollutants, including dust, allergens, volatile organic compounds, and more, can contaminate classrooms. Not only can indoor air pollution cause short- and long-term health issues for employees and students, but it can also lower productivity. It is crucial to have desirable indoor air first-class (IAQ) to assure that teachers and students perform better and are extra effective. A study performed during the week discovered that university college students had been spending a good sized amount of time interior, up to 87% in their time, in which they were challenge to environmental affects. It is critical to investigate how the school room surroundings influences college students' overall performance and health due to the fact they spend lots of time in college and dorms attempting to research. Research has related long-term health problems (e.g., cardiovascular sicknesses, bronchial asthma-related issues) with intellectual health problems that are not right now apparent. The college's interior air can be more contaminated than its outside since the latter has remarkable air flow and no obstructions to the float of air.

The indoor surroundings have a full-size impact on mastering, trendy operating patterns, fitness, and monetary growth. The National Building Code of India Part IV–(2016) divides buildings into nine categories: residential, commercial, commercial, keep, mercantile, academic, institutional, assembly, and unsafe [1].The location and environmental quality of the educational building, as well as a number of building-related aspects like the building's upkeep, cleanliness, and condition, all have an impact on the indoor environmental quality (IEQ), according to the US EPA (2010)[2].

In unique, given that college students spend extra time in the lecture room than in some other internal faculty placing for instructional purposes, the study room's IEQ has a right away impact on student outcomes, which include mastering and pleasure. In order to decide how college college students' happiness with their getting to know settings and publications, in addition to their belief in their mastering, changed into determined, a conceptual model representing several IEQ standards associated with the bodily environment of lecture rooms turned into designed and tested. In the process, a path analysis was carried out to look into the structural links between variables at the same time. This can help us understand more about how planned environments affect human outcomes.

Since one-fifth of the arena's population spends greater than 30% of their time in academic centers such as faculties, universities, and schools, these structures are many of the most significant. The indoor environmental pleasant (IEQ) of any facility is closely correlated with how nicely humans research and execute special jobs. When growing sustainable

instructional facilities, one of the fundamental matters to maintain in mind is indoor environmental fine (IEQ). The domain of "indoor environmental quality" (IEQ) accommodates many sub-domain names that have an impact on the well-being of people living within a structure. Indoor environmental quality of education building is shown in *[Figure-1]*, which is given below.

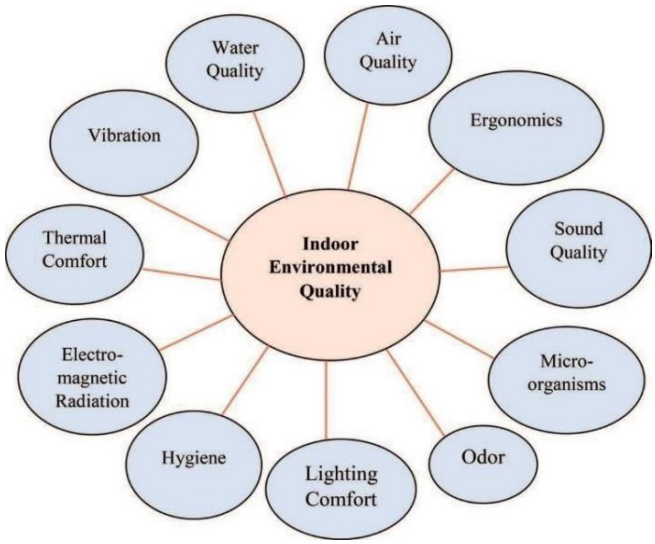

Figure-1: IEQ of Educational Building

The diverse interior areas determined in constructed property, consisting of houses, offices, faculties, and hospitals, make up the indoor surroundings. The state of the indoor environment has been a prominent study is an industry hobby even before the COVID-19 pandemic. Improving the first-rate of lifestyles of constructing occupants, growing work performance or simply in a bid to make a constructing greater sustainable are few motives why studies into IEQ has gained lots of reaction in the AEC industry. IEQ also refers to the quality of a building environment on the subject of the fitness and wellness of folks that occupy space inside it. The IEQ is linked to indoor human comfort that is usually assessed from four factors: thermal, air first-class, visual, and acoustic consolation. Respiratory comfort is commonly expressed as indoor air first-rate (IAQ).

The indoor environment quality of a school facility can be assessed using two different approaches: subjective and objective. Objective evaluation techniques rely on baseline relationships between the environmental circumstances and user satisfaction instead of directly capturing the actual experience of the occupants in order to compress the environmental characteristic using reference ranges of physically acceptable parameters. Methods of subjective evaluation of indoor environmental conditions are assessed using questionnaire-based surveys.

The primary intention of the research is to deal with the pressing want for evaluating and enhancing the indoor environmental excellent (IEQ) of educational facilities, in particular lecture rooms. The purpose of the observe is to envision how students perceive the temperature, lighting fixtures, noise levels, and air first-class as a way to make upgrades on the way to make the gaining knowledge of surroundings extra snug and conducive.

The realization that IEQ significantly affects students' comfort, well-being, and academic achievement served as the driving force. The study aims to create healthier and more productive learning environments for kids by concentrating on educational buildings. Furthermore, the study aims to offer insightful information to lawmakers and educational institutions so they may prioritize IEQ improvements in their buildings, thereby improving the entire educational experience for students.

Additionally, the expanding operations interest in IEQ and the growing emphasis on sustainability and human-centered design in educational environments serve as driving forces for the study. The study aims to address IEQ variables in order to meet the increasing need for environmentally friendly and healthful indoor environments for educators and students. All things considered, the study's purpose stems from the goal to address the critical IEQ features in educational facilities in order to support students' academic achievement and well-being.

2. LITERATURE REVIEW

There are some useful studies in this area. The following are worth mentioning. Orman et al., [3] have resulted that the assessment of the overall comfort of lectures/rooms of an educational building which turned into carried out by the respondents which were gathered with the aid of the questionnaire approach. They in addition analyzed that during this study the bodily parameters of the indoor environment were recorded simultaneously to the process of completing the questionnaire paperwork. Yerragolam et al., [4] have suggested that the method of improving indoor air quality in classrooms of educational buildings by ventilation involves bringing in fresh air and removing stale air. It is the process of controlling indoor air quality and halting the spread of diseases through the fresh air in the classrooms of educational building. To maintain a taller lower layer with a lower concentration of carbon dioxide, we analyses the effectiveness of displacement and down flow ventilation systems in this process. Carslaw et al., [5]are elaborate the five indoor air chemistry in their research work that affects the indoor air quality for classrooms of educational building, which are reactivity in indoor environments, mapping organic constituents indoors classrooms, the role of the occupant in indoor air chemistry, indoor modeling studies, and new materials and modern technologies indoors classrooms. Lee et al.,[6]have elaborated of their study that the preservation improved relative humidity the various

quantitative IEQ parameters, and occupant pride with thermal comfort, air great, overall pride, and general productiveness. The results of the examiner are predicted to be implemented in future discussions concerning occupant satisfaction and to play a massive role in fostering the attractiveness and implementation of constructing renovations to enhance IEQ. Morandi, Pittana, et al., [7] have described in their study, it presents the design and experimental validation of questionnaire, able to capture occupants personal state and satisfaction for the individual aspect so the indoor environmental and its global domains. Mihai and Iordache [8] expanded their investigation to determine specific components of the inner environmental quality of an educational building. They also discovered that numerous essential factors influence the overall best of the indoor surroundings, along with thermal consolation, acoustic comfort, indoor air quality, and visible consolation. This observes became carried out in an educational building. They also spotlight the want to upgrade or renovate homes to improve indoor environmental quality that may result in lower running charges and better occupant productivity. Horr, and Arif et al., [9] their review article focuses on the fact that occupant comfort and well-being is influenced by indoor environmental quality (IEQ).They also described the relationship between IEQ and well-being, highlighting the impact on overall productivity and potential long-term health implications for the population. They also said that building design principles must take into account the needs, comfort and well-being of the occupants. Pistore, et al.,[10] the assessment of indoor environmental high-quality (IEQ) in secondary colleges states that particular emphasis is located on thermal comfort. We also implemented three integrated approaches: objective evaluation by measuring the subjective reactions of students and teachers, and dynamic simulation. They also demonstrated the importance of considering both objective and subjective assessments of his IEQ in educational institutions. Turunen et al.,[11] have a look at investigated how questionnaire-based self-reported signs can be used to examine the prevalence of self-pronounced symptoms amongst students inside the study room and their possible relationship with IEQ in the classroom. Sarbu and Sebarchievici,[12] their study found that energy consumption is highly dependent not only on occupant comfort requirements, but also on building materials, thermo physical properties of buildings, and utility system performance. Mydin et al.,[13] we found that observing relationships between variables and analyzing data is the main purpose of qualitative research methods. We also analyzed the indoor environmental quality, lighting, and thermal comfort of educational facilities. Zhao et al.,[14] stated that indoor environmental nice (IEQ) is likewise stimulated by using pollutants produced in the interior spaces of educational homes. Contaminants that may degrade indoor air first-class (IAQ) in lecture rooms in schooling buildings include mould, micro organism, allergens, unstable natural compound debris (VOCs), and formaldehyde. Persson et al., [15] have centered that making use of energy-effective windows could be an stepped forward association than having a profoundly covered wall without home windows for the instructive structure.

Although the vicinity of glazing has no direct impact on thermal consolation, it does have an impact on the amount of strength used that is associated with the situations of the academic building's interior surroundings.

3. OBJECTIVES

The prime objectives of present study have been given below.

1. To collect the subjective responses for indoor environmental quality in educational building.
2. To examine the parameters of indoor natural nature of an instructive structure and also understand that how the students' perceive the environmental changes.
3. To assess various types of comfort inside the lectures/classrooms of an educational building, it is necessary to investigate comfort and satisfaction, which are considering the thermal, visual and acoustic experiences.
4. To evaluate the contribution of each comfort by using equivalent questions for each indoor natural nature of an instructive structure.
5. To examine the factors affecting the IEQ (overall comfort) for students inside the lectures/classrooms of an educational building during different time period.

4. RESEARCH METHODOLOGY

The objectives of this study are to evaluate the fine of the surroundings in classrooms the use of various parameters which include air great, thermal consolation, visual consolation, acoustic consolation and normal high-quality. The statistics of this look at turned into accrued by survey approach.

This paper came about inside the area-based totally indoor environmental exceptional of an educational engineering college building (lecture / classrooms) of three-story, which might be located in Rajkiya Engineering College, Kannauj, Uttar Pradesh, India. At this instance, the surveying technique has been applied to an experimental research of the evaluation of the interior environmental quality of several lectures and classrooms at the educational building of Rajkiya Engineering College, Kannauj.

4.1 Site and Building

Nine lecture rooms positioned within the instructional constructing of the Rajkiya Engineering College Kannauj, in Uttar Pradesh, India, have been investigated during November 2023 to January 2024.

The weather of Uttar Pradesh is temperate in spring and summer time, warm and dry in summer (average temperature 30°C to 42°C, average most temperature 27°C to 35°C in July), bloodless and arid. Wet in wintry weather (where minimum temperature and January temperature are 17°C and 5°C).

The individuals were students taking guides in those lessons. The researchers emailed 980 college students to fill out the web survey. The survey changed into finished with the aid of 157 college students and the reaction charge turned into sixteen%. There is a massive difference between men (eighty two %) and college students (18%). In addition, many students (77. 9%) spend 3 to four hours per week in one of the lecture rooms.

4.2 Questionnaire Design

Personal information of students (age, gender and clothing stage); diploma of pleasure with temperature, visible, acoustic consolation and indoors best; and general comfort stage turned into evaluated for each query. Students have been asked to rate their emotions of warmth (Available Vocabulary (AMV)) on a scale of 5:2 (2). Additionally, contributors have been asked to fee the sound quality of environments according to every excellent element (thermal delight (TS), sound pride (US), acoustic pleasure (AS), and IAQ satisfaction) and ordinary comfort. To fee mood, 5 points are weighted from -1 to +1 (very dissatisfied, disappointed, neutral, glad and really happy). In the studies, 157 college students crammed out the above survey.

4.3 Model Specification

Correlation and regression analysis techniques have been used to examine the relationship and effects between the IEQ factor (Overall Comfort) and selected predictor variables such as Thermal comfort, Air Quality, and Visual Comfort.

4.3.1 Karl Pearson Correlation Coefficient

The Karl Pearson's Coefficient of Correlation is a parametric measure of the relationship of two continuous variables.

The Pearson's Coefficient of Correlation is given below: -

$$r = [Cov\,(X,Y)/\sigma X \sigma Y]$$

Where, r is the Pearson's Coefficient of Correlation,

σX *and* σY are the standard deviation of the variables.

The Pearson's Coefficient of Correlation lies between -1 to +1.

Symbol, $r = < 1$,

i.e., $-1 < r < 1$.

4.3.2 Regression Analysis

The multiple regression analysis is the useful technique to study the effect of different independent variables or predictor variables on a dependent variable. The multiple regression analysis technique can be employed when the dependent variable is measured on an interval scale. The independent variables are measured preferably in the interval scale, but the method can work when they are measured either in ordinal or in nominal scales. The regression suggests the method attempts to express a dependent variable as a mathematical function of the independent variables. This study is more than one independent variables or predictor variables, so the regression equation is called the multiple regression equation.

The general form of the multiple linear regression models for the analysis has given below: -

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + e_k$$

Where, Y is the dependent variable;

b_0, b_1, b_2, b_3 are the regression Coefficient;

X_1, X_2, X_3 are the independent variables or predictor variable; and,

e_k is the error term.

5. RESULT AND DISCUSSION

The major findings and discussion are made in this study of the indoor environmental quality of educational building which is given below.

5.1 Indoor Air Quality Perception

Taking the classroom climate into consideration was also important for the general purpose of the study. Most participants stated that the air quality was good, which met their needs and contributed to good learning. However, a significant number of people report poor indoor air quality, indicating that there are issues that need to be addressed to improve indoor air quality. Many participants additionally indicated that they were ready to take action in the event that they obtained reviews of awful weather conditions, together with starting or ultimate home windows. This demonstrates the importance of giving students expertise and manipulate over their surroundings, as a result empowering them to

improve the surroundings. Here, the chart of the Indoor Air Quality of educational building is given below in *[Figure-2]*.

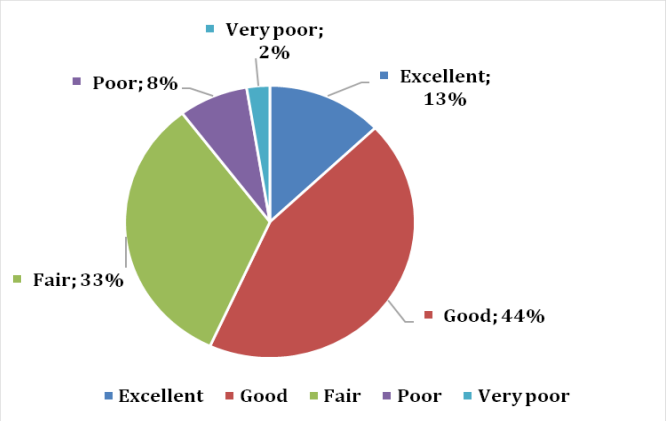

Figure-2: Chart of Indoor Air Quality

5.2 Visual Comfort

Amongst the IEQ indicators is light which was also considered for this studies. On this, most respondents perceived the light degree within the classrooms as okay as proven in *[Figure-3]*, indicating that it become generally exceptional for reading and visual duties. However, a small percent of respondents determined the light stage either too bright or dim, suggesting the need for modifications or upgrades in lighting design. Here, the chart of visual comfort of educational building is given below in *[Figure-3]*.

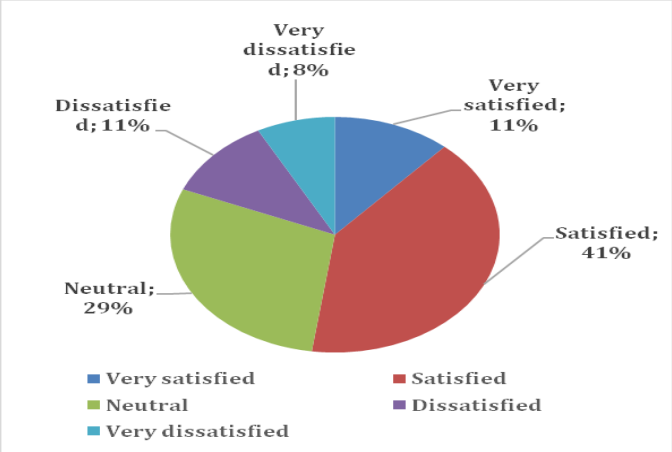

Figure-3: Chart of Visual Comfort

5.3 Thermal Comfort

Among other things, questions were asked about the feeling of warmth in student rooms. As shown in *[Figure-4]*, the analysis confirmed that maximum individuals defined the room temperature as neutral and cool, indicating usual comfort. However, for the reason that facts become collected in the course of the wintry weather months, the fact that the chances are barely less warm shows that there are differences in the temperature conditions in the faculties. But a small percentage felt very cold; this shows that the needs to be improved in cold weather. Here, the chart of thermal comfort of educational building is given below in *[Figure-4]*.

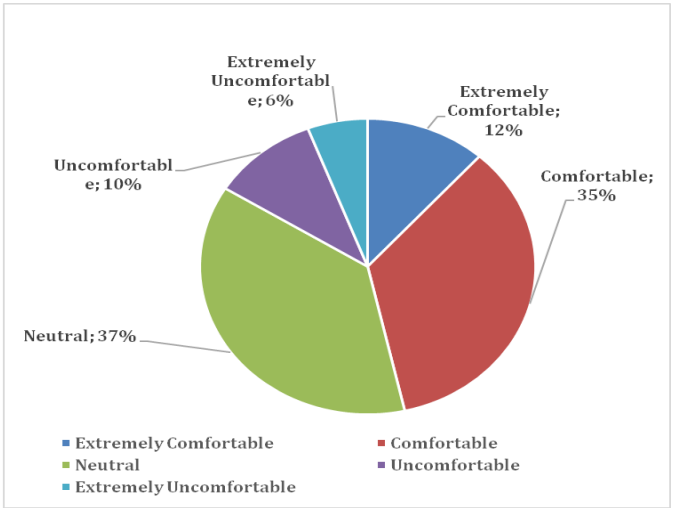

Figure-4: Chart of Thermal Comfort

5.4 Acoustic Level Perception

Another important indicator of IEQ is the noise level evaluated during the research process. External noise was found to be acceptable, although excessive noise that could impair the senses was sometimes reported. Apparently, a large percent verify that noise inside the lecture room impacts their concentration and emphasize the importance of taking measures to govern noise that allows you to research better. Here, the chart of acoustic level notion of educational building has shown inside the *[Figure-5]*.

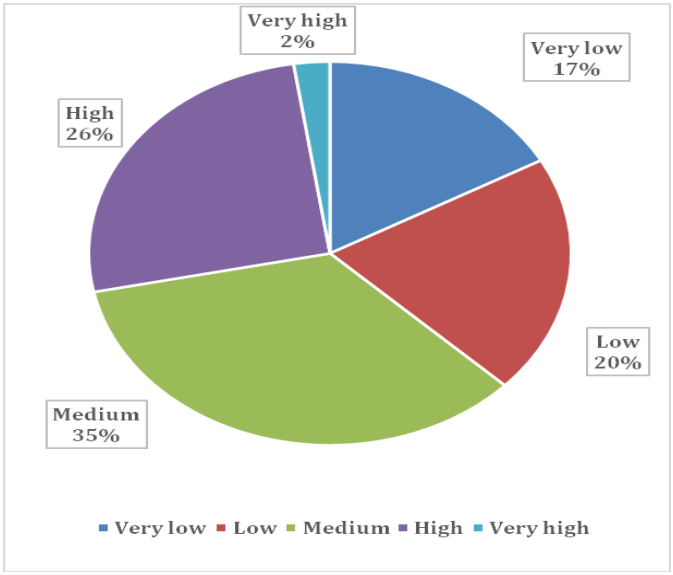

Figure-5: Chart of Acoustic Level Perception

5.5 Overall Comfort

Finally, students recognized the overall impact of IEQ on concentration, with temperature ranking as the most influential factor, followed by air quality, noise, and lighting. These findings provide valuable guidance for improving IEQ in higher education buildings, aiming to create comfortable, healthy, and conducive learning environments that optimize students' well-being and academic performance.

Since data collection was on the 5-point scale and the extremes of the different factors are considered as the dissatisfaction like extreme cold and many more, it can be seen from the *[Table-1]*, that most of the occupants are satisfied with the indoor environment of the building. A series of data analysis procedures was applied. First, the collected data were purified through a standard procedure for handling missing responses, dealing with outliers, and check data quality, assurance and analysis of consistency.

Regarding the thermal environment each floor has maximum comfort during the morning classes except ground floor which shows most satisfaction after 11:50AM (first break). Regarding Indoor Air Quality, ground floor is the best one because it remains almost same whole day while third floor shows most variation, passing through first floor and second floor. It can be seen that most of the time students are satisfied with the lighting conditions of the classroom because of the more number of windows and glass wall, but some students were dissatisfied because of the glare effect. Acoustic environment and insulation are perceived highly satisforty for the majority of the students each floor, but a great percentage of students (18%) feel uncomfortable because of the outside construction at the time of survey.

Table-1: Mean Occupants Satisfaction for IEQ factors of Educational Building

Floor	Factor/ Duration	10:00 AM – 10:50 AM	10:50 AM – 11:40 AM	11:50 AM – 12:40 PM	12:40 PM – 01:30 PM	02:30 PM – 03:20 PM	03:20 PM – 04:10 PM	04:10 PM - 05:00 PM
Ground Floor	Thermal Comfort	3.30	3.43	3.57	3.48	3.13	3.30	3.35
	Air Quality	3.91	3.91	3.96	3.87	3.87	3.83	3.83
	Visual Comfort	3.43	3.43	3.48	3.57	3.43	3.26	3.30
First Floor	Thermal Comfort	3.31	3.29	3.31	3.20	2.97	2.83	3.03
	Air Quality	3.86	3.77	3.60	3.54	3.49	3.54	3.54
	Visual Comfort	3.51	3.49	3.43	3.40	3.34	3.31	3.40
Second Floor	Thermal Comfort	3.35	3.30	3.21	3.12	3.07	3.21	3.16
	Air Qualit	3.23	3.42	3.40	3.35	3.26	3.33	3.16
	Visual Comfort	3.21	3.21	3.35	3.28	3.12	3.16	3.05
Third Floor	Thermal Comfort	3.40	3.33	3.24	3.14	2.98	2.83	3.02
	Air Quality	3.43	3.38	3.40	3.38	3.40	3.24	3.31
	Visual Comfort	3.38	3.48	3.48	3.62	3.55	3.45	3.31

Source: Authors Calculation.

The selected predictor variables for IEQ factors are given in *[Table-2]*, which have been used for the descriptive statistical analysis and correlation and regression analysis.

Table-2: Selected Predictors of Overall Comfort for IEQ of Educational Building

Serial No.	Time	Overall Comfort (Y)	Thermal Comfort (X_1)	Air Quality (X_2)	Visual Comfort (X_3)
1.	10:00 AM – 10:50 AM	10.33	3.34	3.61	3.38
2.	10:50 AM – 11:40 AM	10.36	3.38	3.62	3.40
3.	11:40 AM – 12:30 PM	10.36	3.33	3.59	3.44
4.	12:30 PM – 01:30 PM	10.24	3.24	3.54	3.47

5.	02:30 PM – 03:20 PM	9.90	3.04	3.51	3.36
6.	03:20 PM – 04:10 PM	9.82	3.04	3.49	3.30
7.	04:10 PM – 05:00 PM	9.87	3.14	3.46	3.27

Source: Authors Calculation.

5.6 Descriptive Statistics of IEQ factors

In order to analyze the collected responses, descriptive statistical test has performed as mean, median, and mode for each IEQ factor (temperature, air quality, lighting, acoustics) across each floor of different class durations has calculated. *[Table-3]*, is shown the descriptive statistics of IEQ factors.

Table-3: Descriptive Statistics for IEQ factors of Educational Building

Variables	Mean	Mode	Median	Standard Deviation
Overall Comfort	10.13	10.36	10.24	0.25
Thermal Comfort	3.22	3.04	3.24	0.14
Air Quality	3.55	3.46	3.54	0.06
Visual Comfort	3.37	3.27	3.38	0.07

Source: Authors Calculation.

Now, we have calculated the coefficient of correlation between overall comfort and all selected predictors using Pearson's Correlation analysis method, and ANOVA test by regression model has performed which are given below.

5.7 Correlation of Selected Predictors with IEQ Factors

Here, we have calculated the coefficient of correlation between overall comfort and all selected predictors using Pearson Correlation analysis method. The correlation analysis of the selected predictor variables with the IEQ factor is presented in *[Table-4]*. The table shows that the correlation coefficient of thermal comfort with overall comfort is 0.959. Here the magnitude of correlation coefficient indicates a high positive significant association with thermal comfort and overall comfort. It implies that with increase in amount of thermal comfort, the overall comfort increases accordingly.

Likewise correlation coefficient of the air quality with overall comfort is 0.933. The coefficient indicates a significant positive relationship between the air quality and overall comfort. It implies that if thermal comfort increases then the overall comfort increases significantly.

Table-4: Pearson's Coefficient of Correlation Analysis of IEQ factors

Variables	Overall Comfort	Thermal Comfort	Air Quality	Visual Comfort
Overall Comfort	1.000	0.959**	0.933**	0.802*
Thermal Comfort	0.959**	1.000	0.887**	0.620
Air Quality	0.933**	0.887**	1.000	0.680
Visual Comfort	0.802*	0.620	0.680	1.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Source: Authors Calculation.

5.8 Analysis of Variance for IEQ factors

The ANOVA for this model is given in *[Table-5]*. The value of F is highly significant; so we reject the null hypothesis that all coefficients are simultaneously zero. Value of R, R Square and Adjusted R Square are 0.999, 0.997 and 0.995 respectively. Here, Adjusted R Square is taken into consideration because; the number of observations is less than 50. Also all predictors are entered in the model. Therefore, Adjusted R Square is necessary to examine the variation explained in overall comfort with the help of set of predictor variables.

Table-5: ANOVA Table for Estimated Model of IEQ of Educational Building

Mo	Variable	Sum of Squares	df	Mean Square	F
	Regression	0.37	3	0.12	375.39
	Residual	0.00	3	0.00	
	Total	0.37	6		

Dependent Variable: Overall Comfort.

Predictor Variables: Thermal Comfort, Air Quality, Visual Comfort.

Source: Authors Calculation.

5.9 Regression Results for IEQ factors

Here, overall comfort is dependent variable and the set of other variables are predictor variables. In this analysis, forward step-wise method is used. It is found that only three variables, namely, thermal comfort, air quality, and visual comfort entered in this model. These three predictor variables have jointly explained 99.9 percent variation in overall comfort over the period of time 10:00.AM. to 5:00 PM. Also R Square Adjusted value 99.5 percent is highly statistically significant.

The regression coefficient of variable thermal comfort is 0.59 which is significant. It means that per unit increase indicator of thermal comfort; status of overall comfort is increased by amount of 0.59. This variable is emerged in this analysis as very important for the program point of view for further strategy. The result is given below in *[Table-6]*.

Table-6: Regression Results for IEQ factors of Educational Building

Predictor Variables	Unstandardized Coefficients B	Standard Errors	Standardized Coefficients Beta	t-Statistics
Constant	0.39	0.63		0.63
Thermal Comfort	1.03	0.11	0.59	9.16
Air Quality	0.84	0.28	0.21	3.03
Visual Comfort	1.03	0.14	0.29	7.24

Dependent Variable: Overall Comfort.

Source: Authors Calculation.

6. CONCLUSIONS

The satisfaction score of the occupants for questions for the each floor from G to G+3 of the building were identified to be above average at 2.9, 2.97, 2.7and 2.5 respectively. The four floors of the building were regarded as classrooms and laboratory where, on average, no abnormalities were observed. However, the result from analysing the response data of building through a drill-down and floor-by-floor visualization by survey question, floor, and gender revealed the lowest satisfaction scores for noise-related survey questions. This indicates that the floor-by-floor analysis is necessary to identify IEQ factors and the reasons for the satisfaction of occupants.

Further, the result of the analysis for the responses from all the four floor of academic building at REC KANNAUJ at different timing during the classes showed that the satisfaction level with the noise was low in all floors. The negative effect of noise and poor acoustics on students' productivity is extensively established. Noise from machinery (such as printers, phones etc.) can also expose research building occupants to unwanted noises, and a lack of capacity to control those sounds can reduce productivity. This study also showed that acoustic qualities affect the work productivity and satisfaction of the building occupants.

The results indicate that the lowest scores were given by the third and fourth floor occupants. On the third floor, a biased response was observed because of a temporary event (Another building construction inside the campus). Thus, the scores of responses to certain questions were biased on some floors because of temporary events; this is an inherent characteristic of the survey method, and measures must be implemented to minimize such bias by conducting surveys regularly (e.g., at least quarterly) or before and after a particular (predictable) event.

Monitoring and enhancing the indoor environmental quality in educational buildings contributes to greater performance, a healthy environment, and enhanced instructional activities. Using questionnaire methods of qualitative analysis, this study offers a framework to combine lighting, thermal, visual, and acoustics comfort data for lectures and classrooms of educational buildings.

The study focused on assessing the indoor environmental quality (IEQ) in educational buildings, specifically in classrooms. The findings has revealed insights into students' perceptions of temperature, air quality, lighting, and noise levels, highlighting areas for improvement to create a more comfortable and conducive learning environment. The study also emphasized the importance of addressing thermal comfort, air quality, lighting, and noise control to optimize students' well-being and academic performance for educational building.

REFERENCES

[1] National Building Code of India, Part-4 Fire and Life Safety, Bureau of Indian Standards, Delhi, India, 2016.

[2] US EPA (2010), "Building Air Quality (BAQ): A Guide for Building Owners and Facility Managers", Available at: http://www.epa.gov/iaq/largebldgs/baq page.htm. [accessed March (2014)].

[3] L.J. Orman, N. Siwczuk, N. Radek, S. Honus, J. Piotrowski, L. Debska, "Comparative Analysis of Subjective Indoor Environment Assessment in Actual and Simulated Conditions", Energies (2024), 17, 656. Website: https://doi.org/10.3390/en17030656.

[4] G. S. Yerragolam, C.J. Howland, R. Yang, Richard J.A.M. Stevens, R. Verzicco, D. Lohse, Effect of airflow rate on CO2 concentration in down flow indoor ventilation, Indoor Environments 1 (2024) 100012. Website:

https://www.sciencedirect.com/journal/indoor-environments.

[5] N. Carslaw, G. Beko, S. Langer, C. Schoemaecker, V.G. Mihucz, M. Dudzinska, P. Wiesen, S. Nehr, K. Huttunen, X. Querol, D. Shaw, A new framework for indoor air chemistry measurements: Towards a better understanding of indoor air pollution, Endoor Environments 1 (2024) 100001. Website: https://www.sciencedirect.com/journal/indoor-environments.

[6] J.W. Lee, S.M. Lee, S.E. Lee. Importance of indoor environmental quality surveys for evaluating renovation effects. Journal of Building Engineering 78 (2023) 107726.

[7] F. Morandi, I. Pittana, F. Cappelletti, A. Gasparella, A. Tzempetikos, Assessing Overall Indoor, Environmental Comfort and Satisfaction: Evaluation of a Questionnaire Proposal by Mean of Statistical Analysis of Responses, ASHRAE (2022).(www.ashrae.org).

[8] T. Mihai, V. Iordache, Determining the indoor environment quality for an educational building, Energy Procedia 85 (2016) 566 – 574.

[9] Y. A. horr, M. Arif, M. Katafygiotou, A. Mazroei, A. Kaushik, E. Elsarrag (2015), Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature, International Journal of Sustainable Built Environment (2016) 5, 1–11.

[10] L. Pistore, F. Cappelletti, P. Romagnoni, A. Zonta, Assessment of the IEQ in two high schools by means of monitoring, surveys and dynamic simulation. Energy Procedia 82 (2015) 519 – 525.

[11] M. Turunen, O. Toyinbo, T. Putus, A. Nevalainen, R. Shaughnessy, U. Haverinen-Shaughnessy, Indoor environmental quality in School buildings, and the health and wellbeing of students, International Journal of Hygiene and Environmental Healt, 217, (2014), 5, March,, 733-739. Website: http://www.elsevier. Com/locate/ijheh.

[12] I. Sarbu, C. Sebarchievici, Aspects of indoor environmental quality assessment in buildings. Energy and Buildings, (2013). 60: p. 410-419.

[13] M.A.O. Mydin, N. M. Sani, A, Rahim, M. Ismail, Evaluation of Indoor Environment Quality (IEQ) of Educational Buildings, Journal of Environment and Eath Science ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) Vol 2, No.8, (2012).

[14] Z. Zhao, Z. Zhang, Z. Wang, M. Ferm, Y. Liang, D. Norback, Asthmatic symptoms among pupils in relation to winter indoor and outdoor air pollution in school in Taiyuan, China, Environ Health Perspect 116 (1), 190-197, (2008). Website: http://dx.doi.org/10.1289/ehp.10576.

[15] M.L. Persson, A. Roosa, M. Wall, Influence of window size on the energy balance of low energy houses, Energy and Building (2006), Vol 38, No. 3, p. 181-188.