



Assessing Indoor Environmental Quality of Academic Building Using Subjective Measurement

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ABSTRACT: Indoor Environment Quality (IEQ) is becoming increasingly popular as a means of assessing human comfort, especially in educational environments. Determining an appropriate degree of indoor environment quality (IEQ) involves considering many factors like thermal comfort, indoor air quality, acoustic comfort, and visual comfort. These days, there is an intense need for educational facilities to have high-quality interior environments by reason of the fear of a worldwide pandemic. This research looks into IEQ characteristics in several standard functional locations of a Navsari academic building. In order to assess the level of user satisfaction in the staff room, drawing hall, and classroom, a sequence of questionnaires measuring the subjective aspects of the IEQ parameters (TC, AC, IAQ, and LC) were utilized. According to the study's findings, the summer months had the lowest proportion of TC parameter satisfaction overall and the highest percentage of AC parameter satisfaction. Additionally, the data demonstrates that the satisfaction rate is lower for the LC and IAQ parameters. The research has confirmed that the academic building has low IEQ and It is necessary to take the required steps to turn out a more pleasant, conducive, and productive education place.

KEYWORDS: Indoor environment quality, subjective measurement, satisfaction rate, questionnaires, Acoustic comfort, Thermal comfort

INTRODUCTION

This template provides all the necessary information to the author regarding the formatting specifications needed for preparing electronic versions of their papers. We ask you to make your manuscript look exactly like this document. The easiest ways to do this is simply downloading the template, and replace (copy-paste) the content with your own material. All manuscripts must be in English. This document includes complete descriptions of the fonts, spacing, and related information for producing your proceedings manuscripts. The vast majority of human activity was spent indoors, at around 90%. A person's house is where they spend at least 65% of their time, depending on a number of variables like age, gender, kind of employment, comfort level within and Caliber of interior environment (Leung, 2015). These results recommend that internal ambient factors possess a noteworthy influence on learning, general working habits, health, and economic growth. 'The National Building Code of India Part IV-2016' divides buildings into nine categories: residential, commercial, industrial, store, mercantile, educational, institutional, assembly, and hazardous. Since one-fifth of the world's population spends more than 30% of their time indoors, educational institutions including schools, universities, and colleges are among the most significant structures (Goyal & Khare, 2012).

Structures that satisfy specific requirements are considered to have high-quality indoor environments for human habitation. These standards contain quality of indoor air, comfort in the heat, natural daylight, visual comfort, acoustics, electromagnetic frequency levels, monitoring of working environments, potable waters, functional convenience, and view. The goal of IEQ is to offer comfortable and healthy interior environments for human labour (Lee et al., 2021).

The interior environmental quality (IEQ) of a structure is directly correlated with the learning and task performance. A high IEQ in educational facilities improves students' health and learning capacities while boosting efficiency and production. But there are really not many research studies on school buildings in India, while the greater part of the IEQ studies conducted globally and in India concentrate on residential and commercial structures (M et al., 2022). IEQ is "the quality of a building's environment concerning the health and wellbeing of its occupants and includes aspects of design, analysis, and operation that lead to energy-efficient, healthy, and comfortable buildings," according to "the National institute for occupational safety and health (NIOSH)" 2013 definition.



The health of a building's occupants is directly correlated with its interior conditions. Poor maintenance, a low IEQ, and the age at which the structure are some examples of factors that will deteriorate the building's state and harm the health of its occupants. IEQ deficiencies in educational buildings might lower occupant performance and focus (Suryawanshi et al., 2016). emphasized the advantages of possessing a high IEQ for instructors and students' education and learning. IEQ has a consequence of an employee's self-assurance, output, performance, absenteeism, and work satisfaction (J. Yang et al., 2015).

The IEQ of a building is closely connected to all the causes of sick building syndrome (SBS) and building-related illness (BRI), making it even more crucial to research the IEQ in school buildings (Van Tran et al., 2020). aimed at increasing the necessity of IEQ research in educational institutions. Preschool (kindergarten), elementary school, middle school, upper elementary school, secondary school, and senior secondary school are among the structures that make up schools (Lawrence et al., n.d.). Students in different age groups attend different schools. The Indian educational system has lately undergone modifications as per the National Education Policy 2020, as seen in Figure 1. In India, the government owns and operates over 1.4 million schools. Natural ventilation (NV) accounts for the bulk of school buildings in India, with mixed-mode ventilation serving as the bare minimum (Goyal & Khare, 2012). Particularly in educational facilities where students and staff spend a great deal of time, indoor environmental quality (IEQ) has a significant factor in the health, comfort, and productivity of building occupants. Research indicates that allergies, respiratory disorders, pain, and other health concerns might result from low IEQ. Poor IEQ can further effect on students' academic performance, attendance, and retention in academic facilities (Sun et al., 2015). It is crucial to assess the interior environment quality (IEQ) of academic facilities to ensure that it is safe, cozy and supportive of studying.

IEQ factors

Thermal comfort (TC)

The International Organization for Standardization (ISO) and the American Society of Heating, Refrigerating, and AirConditioning Engineers (ASHRAE) defined thermal comfort as "that frame of mind that conveys contentment with thermal environment" (Mahyuddin & Law, 2019).

Indoor air quality (IAQ)

IAQ is defined as "air in which there are not known pollutants at dangerous amounts as established by competent authorities and with which a large majority (80% or more) of the individuals exposed do not express discontent" by ASHRAE in their indoor air quality guide. Three main elements are involved why maintaining a high-quality indoor air quality is so important (Salamone et al., 2021). The medium of interaction between people, buildings, and weather is indoor air. The physical, biological, and chemical properties of indoor air have a direct impact on building inhabitants' health and wellbeing. Because indoor air quality is simple, it can be precisely defined and controlled to fulfil regulations (Seitablaiev & Umaroğulları, 2018).

Acoustic comfort (AC)

Acoustic comfort (AC) is a crucial IEQ metric that revolves on "noise," or "unwanted sound," which, when it exists in the built environment, interferes with activities, impairs focus, hinders verbal communication and at high levels can seriously impair hearing (Mahyuddin & Law, 2019). Therefore, a building's acoustic comfort refers to its ability to offer an appropriate acoustic environment and noise abatement in compliance with the required acoustic standards. One form of pollution is noise, which makes it clear how important acoustic comfort is for people's health and well-being, productivity, and ability to communicate in a building.

Visual comfort (VC)

IEQ factor for visual comfort includes illumination, which might be artificial or daylighting. It has a crucial an element of the entirety IEQ in educational facilities, as Research has indicated that it is a noteworthy impact on establishing the best possible learning environment. Visual comfort was described as "the subjective visual wellness state resulting from the light environment" by the European Standard (EN 12665) and this description makes it evident that People's beliefs about themselves are influenced by psychological variables overall level of visual comfort (Shet & Professor, 2007). Achievable when There is one favorable balance between the amount and caliber of, occupant perception, and environmental quality of view. While lighting quantity is a reference to output and levels of illumination, lighting quality measures the color and brightness of the light (Z. Yang, 2017).

Thus, this study paper's primary goal is to identify. To get better students' immunity, the research seeks to achieve healthy indoor air quality in educational settings. To this end, the following steps will be taken to monitor the indoor air quality during various



summertime periods and develop recommendations that could be implemented in similar spaces Later on to prevent indoor air pollution:

1. An explanation of the climate and case study region.
2. Subjective evaluation in the summer time staffroom, drawing hall and classroom.
3. Examination of the subjective measurement results.
4. The advice to stay away from indoor air pollution.

The first half portion of the article provides a broad introduction to IEQ and academic buildings. The chosen review approach is described in the second part.

METHODOLOGY

There was also a questionnaire survey. From the three rooms that were examined, 57 completed forms including those from staff and students were gathered. To find out more about the indoor air quality of educational facilities, the research will use a subjective technique.

Subjective measurements

One practical and efficient way to get subjective input on the experiences and opinions of staff and students regarding the standard of the interior environment is via the application of questionnaires. Several factors and possible Research subjects selected for this investigation that including overall satisfaction, light, thermal comfort, air quality in indoor and auditory comfort (Tahsildoost & Zomorodian, 2018).

As per the ISHARE IEQ standard, occupant responses are recorded subjectively using a 7-point rating system tailored to the specific environment. The purpose of the questionnaire is to gather data on the several impacts (sensation, comfort, preference, annoyance, stiffness, and scent) with the purpose of perform an occupant comfort evaluation that is subjective.

The questionnaire captures the qualitative effects of several elements including temperature, relative humidity, air movement, stale air, overall illumination, an outside view and daylight availability. The questionnaire's design makes it simple to record each response using a 7-point rating system. In this case, 1 denotes the most inadequate reaction, and 7 the most excellent one. Every parameter has a percentage satisfaction representation, with responses 1, 2, and 3 being considered unacceptable and responses 4, 5, 6, and 7 being considered satisfactory. The same questionnaire also records a great deal of additional information, including gender, weight, age, height, and the place of origin, which represents tenant anonymity. Buildings categorized as Class A and Class B should, respectively, fulfil 90% and 80% of the satisfaction levels for each element.

Description of the weather circumstances and case study area

The institutional building investigated for this study is situated in the Navsari area and represented a typical Higher Educational building The location of this campus is in a rural region. The summers are hot and dry there (Orola, 2020). The average temperature in these regions is 22°C (72°F) in March and 34°C (93°F) in June, with highs of 39°C (102°F). Peak temperatures in the summertime reach 41°C (106°F), with the sun shining brightly all day long. Three different kinds of learning spaces in the academic building: a drawing hall, a staff room, and a classroom. This gave the chance to ascertain the effect of equipment in a room, furthermore to assist diversify the information and ascertain the degree of comfort in different spaces.

The department academic building is a three-story structure that can accommodate 240 students between the ages of 18 and 23. For the intention of get comprehensive information on the monitored classroom, drawing hall, and staff room additionally to determine indoor air quality, thermal comfort, acoustic comfort and visual comfort a quick survey was carried out.

RESULTS AND FINDINGS

Results of subjective measurements

Survey feedback

The objective behind the questionnaire study was to ascertain renters' level of satisfaction with the four primary categories of interior environmental quality: lighting, noise levels, air quality, and temperature and humidity. The sum of fifty-seven feedback answers were gathered from the locations where measurements and physical surveillance were conducted. The questionnaires were usually



administered at the finish of class (Kapoor et al., 2021). The survey's questions and responses provide insightful information on how inhabitants view the interior environment, presenting the following views and theories.

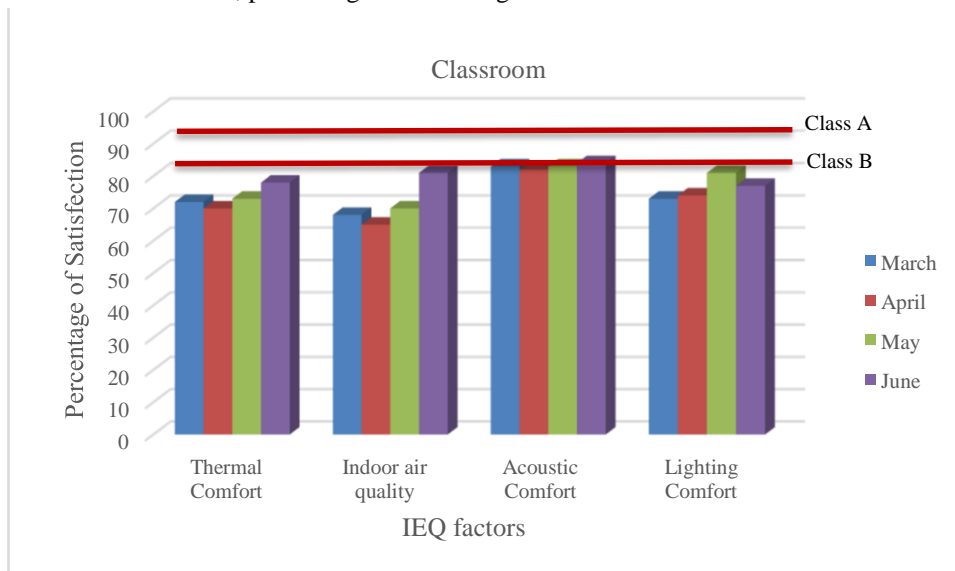


Figure 1: Monthly occupant satisfaction in Classroom

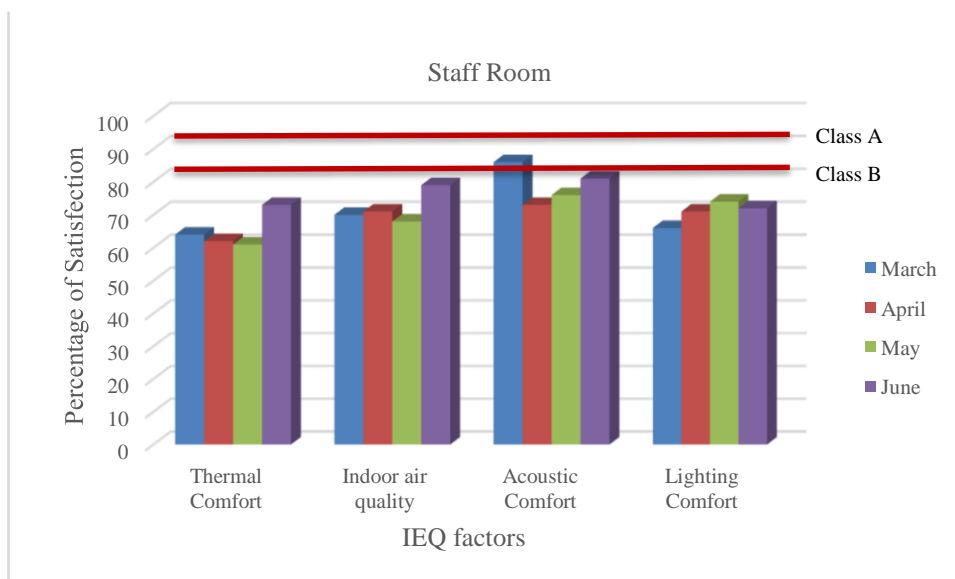


Figure 2: Monthly occupant satisfaction in Staff Room

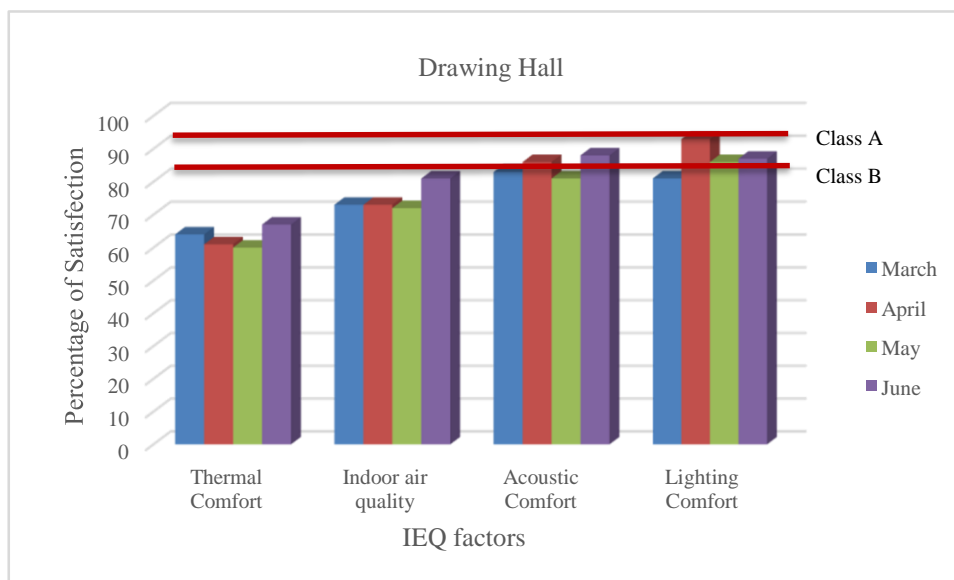


Figure 3: Monthly occupant satisfaction in Drawing Hall

Thermal level in different learning spaces

Among the inquiries made by faculty and students is how they perceive the temperature in the drawing hall, staff room, and classrooms. Figures 1, 2, and 3 illustrate the analysis, which revealed that around 73% of respondents were happy with the thermal level in the classroom, 65% in the staff room, and 63% in the drawing hall. Therefore, it must take the required steps to increase thermal comfort pleasure throughout, especially in the drawing hall in the summer (Nagendra & Harika, 2010).

Level of indoor air quality in different learning spaces

Examining the prognosis for air quality in the staff room, drawing hall, and classrooms was crucial to the overall goals of the study (Assimakopoulos et al., 2008). Among the majority of respondents, as seen in Figures 1, 2, and 3, felt that the state of the air inside in the classrooms, staff room, and drawing hall, respectively, satisfied them to a 71%, 72%, and 75% degree, showing that it lived up to their expectations and contributed to a relaxed learning atmosphere. However, a sizable portion complained about poor air quality, indicating the existence of problems that must be fixed in order to offer the greatest indoor air quality. Furthermore, a noteworthy proportion of participants expressed their readiness to initiate remedial measures, such as shutting or opening windows, in the event of inadequate air quality awareness (Kumar & Tandel, n.d.). This emphasizes how crucial its purpose is to fulfil children knowledge about and control over their surroundings so they may make improvements in the areas right in front of them.

Noise level in different learning spaces

The noise level is another significant IEQ indication that was considered throughout the survey procedure. Figures 1, 2, and 3 illustrate the commonly accepted levels of outside noise; However, there have rarely reports of extremely loud noises that have been known to interfere with concentration. In the staff room, drawing hall, and classroom, the corresponding results for acoustic comfort satisfaction were 83%, 79%, and 85%. Buildings classed as Class B must fulfil 80% of the degree of pleasure with each component, according to ISHRAE regulations. Remarkably, a sizable portion of respondents admitted that noise in the classroom did interfere with their ability to concentrate, highlighting the need of noise management strategies to offer a supportive learning environment (Z. Yang, 2017).

Illumination level in different learning spaces

Another of the IEQ factors that was considered in this investigation was light. As seen in Figures 1, 2, and 3, the common of respondents thought that the light level in the staff room, drawing hall, and classrooms was enough for reading and visual duties. In the staff room, drawing hall, and classroom, the corresponding percentages of satisfaction with lighting comfort were 71%, 71%, and 87%. A tiny minority of respondents, however, thought the light intensity was either excessively bright or too dim, indicating



the need for improvements or modifications to the lighting system. Indoor lighting conditions are the main determinant of visual comfort. One will be able to notice fewer items when there are bad glare phenomena (Z. Yang, 2017). The space's and the windows' shape determine how well and evenly the illumination is distributed. Additionally, the building's energy usage is directly impacted by the appropriate control of lighting.

CONCLUSIONS

Monitoring and enhancing the interior environment quality in educational buildings contributes to the provision of a healthy atmosphere and enhances academic achievement. In order to identify and monitor interior environment issues, this research offers a framework for integrating data on indoor environmental quality in a subjective way. Since this building is far from the road and has no other sources of noise nearby, it has the highest acoustic level satisfaction among all the indoor environmental parameters. The lowest percentage of satisfaction was found in thermal comfort, which directly affects students' ability to concentrate. Several modifications, including scheduling adjustments, using mechanical ventilation, and installing sensors in each room to monitor and regulate the IEQ separately, will enhance the current IEQ both physically and perceptually.

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