Assessing Classroom Indoor Environment from a User-Centric Perspective: A Preliminary Study

Huiying (Cynthia) Hou[1]

ABSTRACT

Background and aim - This paper emphasises the significance of evaluating classroom indoor environment performance from the perspective of students. Recognising this need, this study adopted a user-centric approach to evaluate students' perception of classroom environment based on a university in Hong Kong. The aim was to gain insights into the significance that students attribute to various parameters of the indoor classroom environment.

Methods / Methodology - This study devised and implemented a user-centric performance assessment framework based on the Analytic Hierarchy Process (AHP), as well as a survey based on the framework. 288 students from various types of classrooms participated in the survey, in which they ranked the perceived relevance of multiple classroom environment performance parameters according to their perceived significance. Analysed were the weightings and rankings of the performance parameters.

Results - The ranking results derived from the AHP analysis shed light on the students' perceptions of the relative significance of various environmental parameters. The fact that "facilities and services" received the highest weighting for importance demonstrates the significance of post-occupancy operation management. Male students place more importance on "indoor air quality" than female students do on "thermal comfort" Students in lecture halls prioritise "seating plans" and "temperature" whereas students in general classrooms prioritise "seating layout" and "fire safety".

Practical or social implication - The findings of this study have practical implications for higher education institutions in designing and managing classroom environments. They recommend considering factors such as classroom layout, illumination, temperature control, and acoustics to create optimal learning spaces. By adopting a user-centric approach and actively seeking student feedback, educational institutions can continually improve indoor classroom environments, ultimately contributing to enhanced learning outcomes. Prioritizing comfort, engagement, and adaptability in classroom design can play a pivotal role in promoting academic success in higher education settings.

Type of paper - Full research paper

KEYWORDS

University classroom, classroom environment, student perception, AHP.

INTRODUCTION

The nexus relationships between learning environment, students' psychological/physical condition, and learning outcome have been thoroughly examined in the education literature (Barksdale et al., 2021;

[1] Department of Building Environment and Energy Engineering, The Hong Kong Polytechnic University, cynthia.hou@polyu.edu.hk

Lan et al., 2023). Yet, the learning environment is vaguely defined in these studies, alluding to a hybrid location where learning activities occur. Architectural and engineering literature rarely discusses how students perceive the classroom's internal environment. Yang and Mak (2020) attempted to comprehensively evaluate the building service design aspects of university classrooms and investigated students' perceptions of university classroom engineering design elements. This study analysed the relationship between environmental data (such as thermal environment, acoustic environment, illumination, and indoor air quality) and human perception data (such as satisfaction) for the first time. However, the evaluation of architectural elements in classrooms, which research has shown to have a significant impact on student learning outcomes, was absent from their study. In order to advance Yang and Mak's (2020) research, it is necessary to combine architectural and building services elements into a comprehensive evaluation framework. This study employs a user-centered methodology to evaluate the classroom environment from the students' perspective in order to enhance future classroom management and design. The AHP method was then used to structure and validate the focus group discussion.

LITERATURE REVIEW

Adopting a user-centric approach towards resilient classroom

A user-centric approach shall be adopted in understanding the importance of and satisfaction with the built environment, as highlighted by previous studies examining occupant comfort (Puteh et al., 2015; Mihai and Iordache, 2016; Andargie et al., 2019; Day et al., 2020; Hou et al., 2023a; Hou et al., 2023b). This approach recognizes that the perceived quality of indoor environments, encompassing parameters like thermal comfort, visual comfort, acoustic comfort, and indoor air quality (IAQ), significantly influences occupants' overall comfort and satisfaction. Particularly in classroom settings, where students' well-being is a primary concern, prior research has predominantly focused on the relationships between IAQ and thermal conditions and students' welfare (Mishra et al., 2017; Jiang et al., 2018; Abdel-Salam, 2019; Wang et al., 2021; Rodríguez et al., 2021). While some efforts have been made to integrate holistic indoor environmental quality (IEQ) parameters, such as IAQ, acoustics, noise levels, lighting, and thermal aspects, into these investigations (Bluyssen et al., 2018; Korsavi et al., 2019; Korsavi et al., 2020), these approaches remain less prevalent. Moreover, from a system control perspective, it is essential to consider how IEQ parameters affect system performance in classroom indoor environments. Among building service systems, ventilation systems are frequently scrutinized, given their profound relevance to IAQ and thermal comfort (Gao et al., 2014; Petersen et al., 2016; Dorizas et al., 2018; Liu et al., 2018; Haddad et al., 2021; Choe et al., 2022; Cheng et al., 2022). In essence, adopting a user-centric approach not only improves the understanding of how indoor environmental factors affect occupants but also helps in crafting environments that genuinely enhance well-being and satisfaction, particularly in educational settings like classrooms.

Classroom environment performance parameters

The development of an evaluation framework for university classroom environments hinges on the careful selection of critical parameters. Extensive research in this domain has identified key factors that warrant attention. These encompass indoor air quality, thermal comfort, lighting conditions, and acoustics, as well as considerations related to furniture design, ergonomics, and post-occupancy assessment (Choi et al., 2014; Brink et al., 2021). These studies underscore the significance of parameters such as ventilation, temperature control, lighting quality, acoustic optimization, ergonomic furniture, and the collection of user feedback to inform classroom design and management practices. Of these parameters, thermal comfort emerges as the most commonly studied aspect in university classrooms. Notably, some studies exclusively rely on subjective data to gauge indoor environmental quality (IEQ) performance (Ramprasad and Subbaiyan, 2017), while others adopt an integrative approach by combining both subjective and objective data for a comprehensive analysis (Ricciardi and Buratti, 2018; Zuhaib et al., 2018; Yang and Mak, 2020). This body of research predominantly utilizes subjective data to capture occupants' perceptions of the classroom environment, forming a critical foundation for the development of evaluation frameworks.

In the evaluation of indoor environment quality (IEQ), particularly in university classrooms and higher education institutions, four key performance aspects are commonly assessed:

- Thermal Condition: Among these aspects, thermal comfort stands out as the most frequently examined factor in the context of university classrooms.
- Lighting Condition: Lighting quality, encompassing factors such as illuminance levels, color temperature, and glare reduction, plays a pivotal role in IEQ assessment.
- Acoustic Condition: Effective communication and learning are influenced by acoustic conditions, including ambient noise levels, reverberation time, and speech intelligibility.
- Indoor Air Condition: Indoor air quality (IAQ), which relates to factors like ventilation rates, pollutant control, and their impact on cognitive performance, is another crucial dimension of IEQ assessment.

In the reviewed literature, two distinct approaches to assessing indoor environmental quality (IEQ) in classroom settings were identified. Some studies rely exclusively on subjective data, focusing on occupants' perceptions of the classroom environment, as exemplified by research conducted by Ramprasad and Subbaiyan (2017). In contrast, others take a more comprehensive approach, gathering both subjective and objective data to conduct integrative analyses of IEQ. Notable examples of this approach can be found in the studies conducted by Ricciardi and Buratti (2018), Zuhaib et al. (2018), and Yang and Mak (2020). This multifaceted method combines perceptual insights with quantifiable metrics, offering a well-rounded understanding of IEQ dynamics within classroom environments.

METHODOLOGY

AHP method and its application in the study

The aim of this study is to evaluate the indoor environment from the perspective of students. Analytic hierarchy process (AHP) is considered to be suitable for this user-centric approach because it allows students to provide input and weight the importance of different parameters according to their own perceptions and priorities. AHP is a well-established method for decision-making and problem-solving that allows for a structured and comprehensive evaluation of multiple criteria. In the context of assessing classroom indoor environment performance, it provides a systematic way to consider various factors simultaneously, reflecting the complex nature of indoor environments. AHP is adept at combining quantitative data (e.g., rankings of parameters) with qualitative data (e.g., students' perceptions), providing a balanced view of the indoor environment's significance based on both objective and subjective measures (Hou et al., 2020).

Regarding the selection of pairs of environmental parameters, the process likely involved careful consideration and students' judgment. The application of AHP usually begins with a comprehensive list of potential criteria and then narrow them down through a series of steps:

- Initially, all relevant parameters are identified based on existing literature, expert opinions, and the study's objectives. This step aims to encompass as many relevant aspects as possible.
- The AHP process involves comparing each parameter with every other parameter to establish their relative importance. These pairwise comparisons are usually conducted through surveys or expert consultations.
- The collected data from pairwise comparisons are often normalized to ensure consistency and meaningful comparisons. This step helps create a consistent scale for assessing importance.
- With the normalized data, the AHP algorithm is applied to calculate the final weights and rankings of the parameters.

Development of performance assessment framework (AHP hierarchy)

The process of developing and selecting the evaluation framework involved a series of five Focus Group Discussions (FGDs). In each FGD, students were encouraged to freely discuss their perceptions of classroom environments based on their personal experiences at the university. The participants were guided to collaboratively construct a hierarchical framework for assessing classroom performance, drawing from their own interactions with various classrooms. The researcher played the role of a moderator, maintaining objectivity and ensuring that the participants' opinions were the focal point. The initial objective of the first four FGDs was to co-create a framework for evaluating classroom performance, with the participants actively contributing their insights. At the conclusion of each FGD, the facilitator presented the evolving framework to the participants for confirmation and feedback. In the fifth FGD, participants were presented with four different evaluation frameworks developed in previous sessions. They were invited to provide comments on the suitability of these frameworks. Subsequently, participants engaged in a voting process to determine the most appropriate evaluation framework among the options. A three-level classroom environment performance assessment framework was then developed based on the results of the FGD (Figure 1).

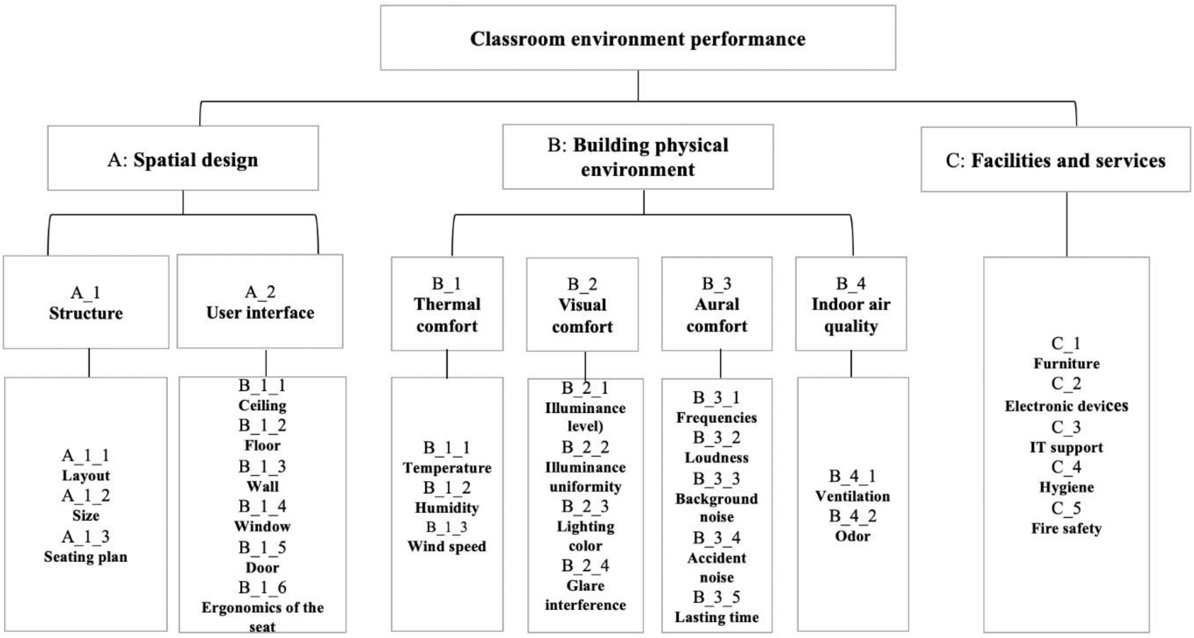

Figure 1 Classroom environment performance assessment framework.

Questionnaire design and distribution based on AHP method

Students with different academic background and education level will be randomly sampling for the survey participation. Instead of approach individual students, the research team will approach instructor from different departments for their support to deliver the questionnaires in their class. During the survey, students will be asked to indicate their perceived importance of the main level and sub-level of classroom IEPs based on an AHP-based questionnaire-survey. Students will be asked to make pairwise comparisons of the indoor environment parameters included in the framework. AHP method is one of the multi-criteria decision-making tools facilitating individual to decide the importance level among multi criteria. As the AHP method gives advantage in mapping out the hierarchical relationships and the interactions among sub-criteria, it is commonly used in decision-making processes that require a high level of fuzzy logic. An example of the pairwise comparison of each pair of indoor environment parameters is illustrated in Figure 2. Students are required to respond to a series of pairwise comparisons of two IEPs or two clusters to be evaluated in terms of their contribution to their particular upper-level criteria. Interdependencies among IEPs of a cluster must be examined pairwise; the influence of each element on other elements can be represented by an eigenvector. The relative importance values are determined with Saaty's 1–9 scale (Figure 2), where a score of 1 represents equal importance between the two elements and a score of 9 indicates the extreme importance of one element (row cluster in the matrix) compared to the other one (column cluster in the matrix).

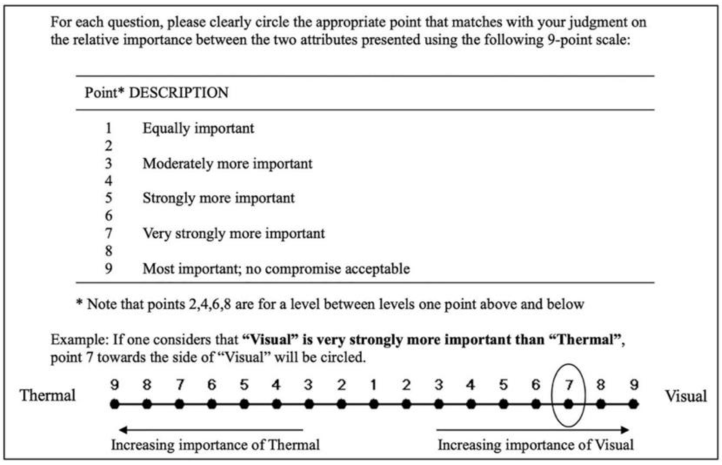

Figure 2 Example of the pairwise comparison between each pair of indoor environment parameters.

AHP method is a quantitative and qualitative decision analysis technique that has been widely used in studies to facilitate decision-making. The AHP, which was first proposed by Saaty (Saaty, 2003), is used to obtain the weighting vectors of the three-level multi-criteria evaluation model.

In this study, the final version of classroom environment performance evaluation framework includes three hierarchical levels. The second step is to establish the pairwise comparison matrix. Under the hierarchical structure, a pairwise comparison matrix can be generated by Equation (1). The next step is to calculate the weighting vectors of each level using Equation (2), wi represents the weighting of each factor. The last step is to test the consistency. The consistency index (CI) and the consistency ratio (CR) are utilized to determine the consistency of pairwise comparisons and the matrix, respectively, as shown in Equation (3). λmax is the eigenvalue; and n represents the number of factors in the pairwise comparison matrix. Generally, CR ≤ 0.1 indicates that the consistency of the pairwise comparison matrix is acceptable.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j} \\ a_{21} & a_{22} & \cdots & a_{2j} \\ \cdots & \cdots & \cdots & \cdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} \end{bmatrix}, a_{ij} = 1/a_{ji} \ (i = 1,2,3, \dots n, \text{and } j = 1,2,3, \dots m) \quad (1)$$

$$W=[w1, w2, \dots, wn], w_i = \frac{\sum_{j=1}^{n} \bar{a}_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \bar{a}_{ij}}, \quad (2)$$

$$CI = \frac{\lambda_{max} - n}{n - 1}, CR = \frac{CI}{RI} \quad (3)$$

In this study, it was used to solicit students' stated preference between pairs of the aspects of classroom environment parameters based on their experience with the classroom environment. After completing a series of pair-wise comparisons composed by the performance aspects from the evaluation framework, the student's ranking of the performance aspects is obtained, which indicate his / her perception of the performance of the classroom environment.

RESULTS

A number of 288 valid questionnaire were obtained. The students were randomly approached in different classrooms across different buildings in the university. These classrooms are mainly divided into two types: lecture theatre and general classroom. The results of the 288 questionnaire passed the consistency check. The AHP rankings of all the indoor environment parameters are outlined in Table 1. Table 2 illustrates the AHP ranking by groups: gender and classroom types. Students were asked to indicate their gender and the venue they completed the questionnaire survey. Those who stayed in the classroom indicated “classroom” as venue while those who stayed in the “lecture theatre” selected “lecture theatre”.

In Table 1, the weightings and rankings of the performance parameters are structured within a hierarchy, facilitating clear comparisons both within and between levels. Notably, "facilities and services" emerged with the highest importance weighting, accounting for 38.93%, followed closely by "spatial design" and "building physical environment" at 32.25% and 28.83%, respectively. This finding holds significance as it highlights that, despite receiving relatively less attention during the building design and construction phases, "facilities and services" are of utmost importance to the students at the investigated university. This underscores the critical role of post-occupancy operation management. Additionally, it reflects the scientific rigor of the framework development process. Versions 1-3 of the framework did not place "facilities and services" on the same level as other environmental factors, potentially leading to an oversight of the high value students place on this aspect. This underscores students' elevated attention to "facilities and services" in comparison to "spatial design" and "building physical environment. At the second level, the weighting gap values between "structure" and "user interface" are quite similar, with less than a 3% difference. However, students tended to attribute slightly higher importance to "user interface." A similar pattern emerges with parameters such as "indoor air quality," "visual comfort," "thermal comfort," and "acoustic comfort," with "indoor air quality" perceived as slightly more important than the other three. The weightings and rankings serve as direct indicators of students' perceived importance regarding these environmental parameters at each level and category. This information provides valuable insights for facilities managers, offering a concise overview of students' needs and preferences in the classroom environment. It aids in making informed decisions and prioritizing improvements that align with the priorities and expectations of the students.

Table 1 AHP ranking of all the indoor environment parameters.

Hierarchy level	Code	Indoor environment parameters	Weighting	Ranking
Level 1	U_1	Spatial design	32.25%	2
	U_2	Building physical environment	28.83%	3
	U_3	Facilities and services	38.93%	1
Level 2	U_{1_1}	Structure	48.97%	2
	U_{1_2}	User interface	51.03%	1
	U_{2_1}	Thermal comfort	24.94%	3
	U_{2_2}	Visual comfort	25.27%	2
	U_{2_3}	Acoustic comfort	23.82%	4
	U_{2_4}	Indoor air quality	25.97%	1

	U_{3_1}	Furniture	24.55%	1
	U_{3_2}	Electronic devices	15.02%	5
	U_{3_3}	IT support	16.97%	4
	U_{3_4}	Hygiene	19.88%	3
	U_{3_5}	Fire safety	23.58%	2
Level 3	$U_{1\_1\_1}$	Layout	33.55%	2
	$U_{1\_1\_2}$	Size	31.44%	3
	$U_{1\_1\_3}$	Seating plan	36.68%	1
	$U_{2\_2\_1}$	Ceiling	14.34%	5
	$U_{2\_2\_2}$	Floor	14.42%	4
	$U_{2\_2\_3}$	Wall	12.79%	6
	$U_{2\_2\_4}$	Window	18.55%	2
	$U_{2\_2\_5}$	Door	15.50%	3
	$U_{2\_2\_6}$	Ergonomics of the seat	24.39%	1
	$U_{2\_1\_1}$	Temperature	36.12%	2
	$U_{2\_1\_2}$	Humidity	27.74%	3
	$U_{2\_1\_3}$	Wind speed	36.14%	1
	$U_{2\_2\_1}$	Illuminance	21.26%	4
	$U_{2\_2\_2}$	Illuminance uniformity	23.48%	3
	$U_{2\_2\_3}$	Lighting colour	28.16%	1
	$U_{2\_2\_4}$	Glare interference	27.10%	2
	$U_{2\_3\_1}$	Frequencies	20.16%	3
	$U_{2\_3\_2}$	Loudness	17.23%	5
	$U_{2\_3\_3}$	Background noise	18.24%	4
	$U_{2\_3\_4}$	Accident noise	21.94%	2
	$U_{2\_3\_5}$	Lasting time	22.43%	1
	$U_{2\_4\_1}$	Ventilation	50.44%	1
	$U_{2\_4\_2}$	Odor	49.56%	2

The AHP rankings by different gender and different venue (where they completed the survey) reveal certain level of differences in the ranking. For example, male students and female students ranked the parameters under “building physical environment” differently. Another example is that students who stayed in the classroom regarded “fire safety” the most important while those who stayed in the lecture theatre considered “furniture” the most important.

Table 2 AHP ranking of indoor environment parameters by groups (gender; classroom type).

Hierarchy level	Code	Performance attributes	Female		Male		Lecture theatre		General classroom	
			W	R	W	R	W	R	W	R
Level 1	U_1	Spatial design	32.74%	2	31.88%	2	30.77%	2	34.65%	2
	U_2	Building	28.73%	3	29.31%	3	28.29%	3	30.16%	3
	U_3	Facilities and	38.53%	1	38.81%	1	40.94%	1	35.19%	1
Level 2	U_{1_1}	Structure	49.19%	2	48.92%	2	49.76%	2	48.07%	2
	U_{1_2}	User interface	50.81	1	51.08%	1	50.24%	1	51.93%	1

	U_{2_1} Thermal	25.77%	1	23.62%	3	24.92%	2	25.02%	3
	U_{2_2} Visual comfort	24.88%	2	25.91%	2	24.73%	3	25.96%	2
	U_{2_3} Acoustic	24.78%	3	22.33%	4	24.21%	4	22.93%	4
	U_{2_4} Indoor air	24.57%	4	28.14%	1	26.14%	1	26.08%	1
	U_{3_1} Furniture	24.02%	1	25.00%	1	26.93%	1	19.50%	3
	U_{3_2} Electronic	15.49%	5	14.61%	5	14.41%	5	16.13%	5
	U_{3_3} IT support	17.40%	4	16.73%	4	17.06%	4	17.06%	4
	U_{3_4} Hygiene	20.01%	3	20.16%	3	19.30%	3	21.32%	2
	U_{3_5} Fire safety	23.07%	2	23.51%	2	22.30%	2	25.99%	1
Level 3	$U_{1\_1\_1}$ Layout	33.43%	2	31.74%	3	32.97%	2	32.03%	3
	$U_{1\_1\_2}$ Size	29.97%	3	32.85%	2	30.75%	3	32.41%	2
	$U_{1\_1\_3}$ Seating plan	36.59%	1	35.41%	1	36.28%	1	35.56%	1
	$U_{2\_2\_1}$ Ceiling	14.55%	5	14.33%	4	14.46%	4	14.42%	5
	$U_{2\_2\_2}$ Floor	16.23%	4	12.69%	6	13.43%	5	16.15%	4
	$U_{2\_2\_3}$ Wall	12.53%	6	13.21%	5	12.24%	6	13.79%	6
	$U_{2\_2\_4}$ Window	19.41%	2	27.77%	1	18.46%	2	17.81%	2
	$U_{2\_2\_5}$ Door	16.21%	3	14.87%	3	14.57%	3	16.84%	3
	$U_{2\_2\_6}$ Ergonomics of	21.08%	1	17.13%	2	26.83%	1	20.97%	1
	$U_{2\_1\_1}$ Temperature	37.34%	1	33.78%	2	37.28%	1	34.68%	2
	$U_{2\_1\_2}$ Humidity	27.21%	3	28.41%	3	27.75%	3	27.64%	3
	$U_{2\_1\_3}$ Wind speed	35.45%	2	37.81%	1	34.97%	2	37.68%	1
	$U_{2\_2\_1}$ Illuminance	20.41%	4	21.88%	3	23.05%	4	19.68%	4
	$U_{2\_2\_2}$ Illuminance	24.88%	3	21.83%	4	23.57%	3	23.55%	3
	$U_{2\_2\_3}$ Lighting colour	27.82%	1	28.74%	1	26.92%	1	29.32%	1
	$U_{2\_2\_4}$ Glare	26.89%	2	27.55%	2	26.46%	2	27.45%	2
	$U_{2\_3\_1}$ Frequencies	19.70%	3	20.52%	2	19.51%	3	20.39%	3
	$U_{2\_3\_2}$ Loudness	17.87%	5	16.04%	5	16.84%	5	17.91%	4
	$U_{2\_3\_3}$ Background	17.95%	4	19.09%	4	18.90%	4	17.67%	5
	$U_{2\_3\_4}$ Accident noise	22.79%	1	20.32%	3	21.98%	2	22.09%	1
	$U_{2\_3\_5}$ Lasting time	21.69%	2	24.04%	1	22.77%	1	21.95%	2
	$U_{2\_4\_1}$ Ventilation	49.40%	2	52.18%	1	48.84%	2	53.20%	1
	$U_{2\_4\_2}$ Odor	50.60%	1	47.82%	2	51.16%	1	46.80%	2

The key findings of this study reveal noteworthy differences in perception between male and female students. While the perceptions of "spatial design" (U1), "building physical environment" (U2), and "facilities and services" (U3) are relatively consistent between both genders, significant variations emerge in the second-level categories, specifically concerning "thermal comfort" (U2_1), "visual comfort" (U2_2), "acoustic comfort" (U2_3), and "indoor air quality" (U2_4). Male and female students markedly differ in their views regarding these parameters. Notably, male students attribute greater importance to "indoor air quality" (U2_4) compared to the other three performance measures, whereas female students prioritize "thermal comfort" (U2_1) as the most significant factor. The small weighting gaps among these indicators emphasize the significance of sub-groups within "thermal comfort" (U2_1) and "indoor air quality" (U2_4). Within the sub-group "thermal comfort" (U2_1), which includes "temperature" (U2_1_1), "humidity" (U2_1_2), and "wind speed" (U2_1_3), female students allocate weightings of 37.34%, 27.21%, and 35.45%, respectively, while male students distribute weightings of 33.78%, 28.41%, and 37.81%. This divergence indicates that female students are more concerned about the classroom temperature, while male students exhibit a higher sensitivity to wind speed. Furthermore, within the "indoor air quality" (U2_4) sub-group, female students express a preference for "odor" (U2_4_2) over "ventilation" (U2_4_1), whereas male students prioritize ventilation. This divergence is noteworthy because ventilation significantly impacts wind speed, suggesting that male students are more attuned to airflow in the classroom, while female students are particularly sensitive to temperature. These findings shed light on the differing priorities and sensitivities of male and female students, with females placing a stronger emphasis on temperature, and males being more attentive to airflow. Understanding these nuances in perception is valuable for tailoring classroom environments to better suit the needs and comfort of both genders.

For students from two different types of classrooms, both groups of students regarded "seating plans" (U1_1_3) as the most significant factor. However, students who remained in the lecture theater rated "layout" (U1_1_1) as more significant than "size" (U1_1_2), which contrasts with the perceptions of those in general classrooms. This suggests that students in lecture theaters believe there is ample space, making the "size" of the lecture theater less critical. Another noteworthy finding is that students who remained in the lecture theater considered "temperature" (U2_1_1) the most significant factor, while those in general classrooms prioritized "wind speed" (U1_1_3). This indicates that students in lecture theaters are more temperature-sensitive. Additionally, those in lecture theaters expressed greater concern about "furniture" (U3_1) than "fire safety" (U3_5), while students in general classrooms ranked "fire safety" (U3_5) as the most crucial factor, followed by "hygiene" (U3_4) and "furniture" (U3_1). Moreover, students in lecture theaters assigned a higher rank to "odor" (U2_4_2) than "ventilation" (U2_4_1), whereas those in general classrooms held different priorities. These findings reveal nuanced differences in the perceptions of students based on the type of classroom environment they occupy. Students in lecture theaters appear to prioritize factors like temperature and seating layout, while those in general classrooms place greater importance on factors such as wind speed, fire safety, and ventilation. Understanding these distinctions can inform classroom design and management strategies to better cater to students' needs and preferences.

DISCUSSION AND CONCLUSION

This study makes a significant contribution by employing a systematic grouping approach to extract specific user preferences from a highly homogeneous group of university classroom users. Since the participants in this study all belonged to the same university, they shared a remarkable degree of homogeneity in their attributes. Utilising this systematic grouping method allowed for a nuanced understanding of the specific preference variations among these students. The disparities identified during the series of five focus group discussions were then translated into distinct performance evaluation framework, each tailored to the characteristics and perspectives of the respective student groups.

In the analysis of survey results, commonly utilised grouping criteria such as gender and classroom types were applied to explore inter-group disparities. Although students from different groups. For example, male students prioritised indoor air quality as the most crucial factor, while female students gave precedence to thermal comfort. This finding aligns with prior research on interior environmental quality, which has investigated how males and females perceived indoor thermal conditions differently.

The results provide insights into which aspects of the indoor environment are considered most important by students. This information can guide educational institutions, facility management (FM) professionals, and designers in making informed decisions about resource allocation and improvements. For the FM industry, knowing which parameters hold the highest importance to users can assist in prioritizing maintenance and improvement efforts. Resources can be allocated more efficiently to address areas that have the greatest impact on user satisfaction and well-being. For researchers, understanding the relative importance of different parameters can inform future research directions. It can help identify areas where more in-depth investigation is needed and guide the development of targeted interventions and solutions.

Utilising the developed assessment framework in a case study conducted at a university in Hong Kong, the study uncovered students' perceived importance of classroom environment parameters. The investigation delved into the importance ranking of performance parameters in university classroom across various sub-groups, including gender, and classroom type. The findings of this study will aid facilities managers in gaining a deeper understanding of students' distinct needs and preferences concerning the indoor environment, ultimately facilitating more effective classroom management and improvement tailored to specific user groups.

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