# AN ASSESSMENT OF STUDENT'S COMFORT IN HIGHER EDUCATION BUILDING OF PAKISTAN

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## ABSTRACT

Comfort assessment, as defined in the literature, is an evaluation of the quality of indoor building environments through user perception. Considering its criticality in the educational institutes, this study was aimed to assess the students' comfort level in the universities of Pakistan, so that proper measures can be carried out to upgrade the classroom's environment. Mehran University of Engineering and Technology, Jamshoro, Pakistan was selected as the study area. Two departments, namely the Architecture Department and City and Regional Planning (CRP) Department were randomly selected. With an interval of ten, a sample of twenty-seven students was selected using Systematic Sampling Technique. The data was analyzed using frequency distribution and Likert-scale index score method. Results showed strong satisfaction with the seating and acoustic quality, whereas dissatisfaction with the visual, ventilation and thermal qualities were observed. Classrooms of the Architecture Department with moderate room temperature had minimal access to sunlight and air. While the classrooms of the CRP Department had extreme temperature gain with excess sunlight and glare both during summer and winter season. Thus, it was proposed that the problematic conditions in these two Departments should be addressed at the earliest to improve the comfort level. Findings, also proposed the necessity to include such variables in the annual student's feedback. Likewise, it was argued that a similar approach could be adopted for other institutes to make the classrooms comfortable.

***Keywords:*** Comfort Assessment, Higher Education, University, Likert-scale, Frequency Distribution.

## INTRODUCTION

Comfort assessment is the process of examining the mental state that articulates satisfaction with the indoor building environment, as defined by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (Ashrae, 2009). The assessment is done by evaluating Indoor Environmental Quality (IEQ), Indoor Air Quality (IAQ), thermal, visual, seating, and acoustic comfort (Akande and Adebamowo, 2010). However, satisfying the comfort of every user in a building is a difficult task as the physiological and psychological condition of each person is different. Still, comfort assessment is considered among the most influential factors impacting ecology and building sustainability (Nasrollahi, et. al., 2008).

Providing comfort is fundamental, but ensuring its provision has become tough due to global climate change and global warming (Akande and Adebamowo, 2010). According to the literature, buildings, especially educational buildings, are the highest energy-consuming segment of the urban environment as they consume forty percent of the total generated energy. This makes educational buildings a prime focus of energy-saving policies and procedures. Furthermore, the increasing concentration towards human livability indicates an escalating emphasis on the true meaning and evaluation of urban heat island prerequisites. These days, users' comfort about the Indoor Environmental Quality (IEQ) that incorporates ventilation, thermal, visual, lighting, acoustic and seating comfort is thought of as a critical measure to define the structure efficiency and is closely interrelated to energy performance (Akande and Adebamowo, 2010). Perceived from this point of view, the overall functionality

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and improvement of any structure are as crucial as its designing due to the interlinkages between structure functionality, energy efficiency and comfort. These can be assessed through comfort assessment (Akande and Adebamowo, 2010).

Academic buildings are considered exceptional case due to their uniqueness in terms of users, actions and building use patterns (Allab et al., 2016). Realizing that students spend about a quarter of a day at educational institutes, they are the areas of concern, regarding environmental quality (comfort) for the betterment of students. The information regarding the degree of comfort is essential to ensure quality in the indoor building environment of educational buildings, especially in developing countries. In the educational buildings of developing countries, such as Pakistan, priority is given to the physical aspects only. The building quality is usually evaluated on its aesthetics and structural design. Thus, factors affecting the user's comfort are not generally considered. As a result, the structures lack proper ventilation and have other associated issues. Such situations are mainly observed in the planning and design of educational buildings, where differentiating an educational building from a residential building seems a difficult task.

Like other campuses and educational institutes around the globe, the students of Pakistani universities face several problems regarding thermal, ventilation, lighting, visual, seating and acoustic comfort in their classrooms. These problems adversely affect their concentration and interest during lectures and other academic activities. In the past years, the literature showed achievements of on-site evaluations to determine the weak points of a structure and to propose optimum recommendations. Hence, the literature emphasizes to conduct building audit of academic institutes. A number of projects and programs, such as Renewschool, and Alliance K-12 are being observed worldwide which contributes towards comfort assessment (ASE, 2019, Renew-School, 2019). Similarly, year-wise feedback is conducted in almost all universities in Pakistan, but it does not include the students' comfort aspect. Without the evaluation of students' comfort, it is impossible to make the departmental buildings comfortable, energy-efficient and sustainable. Therefore, an exercise involving evaluation of the students' comfortability in higher education institutes of Pakistan was carried out for this research so that proper measures could be outlined for betterment in the classroom environment. The study, thus, highlighted the factors affecting students' comfort by evaluating their level of satisfaction with their respective departmental buildings.

## LITERATURE REVIEW

Heracleous and Michael (2018) investigated the indoor and outdoor comfortability in the high school classrooms, by investigating temperature and humidity in association with the carbon dioxide emission levels. Investigation showed exceeding values of temperature and humidity. They proposed variations in ventilation and opening patterns to improve air quality and minimize heat loss.

Responding to the shortcomings of classroom comfort data, Rodriguez et al. (2019) improved post-occupancy surveys by proposing the inclusion of physical, environmental, physiological and psychological parameters with variables like environment, layout, amount of habitation and social backgrounds to make the survey more comprehensive. De Angelis et al. (2017) introduced a less complicated method for bioclimatic design strategies, by comparing the examined simulations with the characteristics of ideal well-being to assess the capability of structure technologies. Using questionnaire survey and instrumentation data, Papazoglou et al. (2019) applied projected average value and proportion of disappointed indexes for evaluating the user's opinion regarding thermal comfort. They suggested that understanding the perception of building users is the first and foremost element to save electricity consumption and for reducing carbon dioxide production. As perception regarding the users comfort of our study area is unavailable to date, this study attempted to provide such information with an intention to protect urban microclimate and air quality. Zomorodian et al. (2016) reviewed the results of comfort field surveys in Iran's educational buildings of last fifty years to determine the optimum methodologies and evaluate results based on the methodology. They found that majority of the studies showed students dissatisfaction with the ventilation, temperature and indoor air, for which serious efforts are needed.

El-Darwish and El-Gendy (2018) used questionnaires for capturing the students' opinions about the thermal comfort of higher educational buildings in Egypt. The study found a disparity in results as indoor building environments were uncomfortable and unresponsive to the students' needs. With a sample of thirty two buildings and a five-and-seven point Likert scale questionnaire, Kumar et al. (2016) examined the thermal comfort in India. Variables like wind temperature, comparative moisture and wind speed were used. In the end, they suggested managing wind speed to enhance thermal comfort. Bortolini and Forcada (2019) introduced a statistical approach as a means of examining to evaluate the sustainability of structures in Spain. In a comfort assessment study of Singapore, Shan et al. (2018) adopted a seven-point Likert scale to examine the impacts of indoor thermal quality and air quality on the wellbeing of students. Then, the performance was compared with metrics of other structures via the life cycle costing case study. The results emphasized improvements in the thermal quality and air quality as it could enhance the wellbeing and performance of the students during their academic hours. To fill up the gap between scientific literature and practical applications, Hellwig et al. (2019) suggested the application of adjustable thermal comfort rules in the layout and functionality of structures (especially educational institutes) to enhance energy efficiency.

On a university campus of France, Allab et al. (2017) conducted energy and thermal comfort assessment for constructing and developing an energy appraisal procedure. They introduced a transverse approach by combining the questionnaire responses, observations and physical measurements that could assist in understanding the indoor building environment. Another study of France described an approach for building audits by investigating energy consumption and indoor air quality levels . Also, Likert-scale based questionnaire survey was used to record subjective measurements. Both approaches could be used to suggest the most optimum recommendations to improve the comfortability of indoor building environment. To examine the thermal comfort in universities of Brazil, De Abreu-Harbich et al. (2018) analyzed the architectural design, conducted field surveys, recorded the response of students and applied simulation. In a sample of two hundred users, they found dissatisfaction with natural ventilation, evaporative cooling and air conditioning as the obtained values did not meet the prescribed regulations.

**Determinants of Comfort Assessment**

**Visual / Lighting Comfort**

Unlike other variables of comfort assessment, visual comfort is considered a prominent factor in determining the efficiency of educational buildings. Using a questionnaire survey based on a Likert scale, Korsavi et al. (2016) investigated the visual comfort in sunlight and non-sunlight classroom areas, of a high school in Iran. Results declared neutral response of pupils in both areas as they did not sense open sunlight and glare. A study of the United Kingdom investigated the impact of thermal and visual comfort on power utilization by monitoring the temperature and lighting levels of academic institutes. The outcome showed greater use of energy in hours when the requirements of thermal and visual comfort were not met. In Cyprus, Michael and Heracleous (2017) examined the performance of natural lighting in schools using a Likert-scale based questionnaire survey with a sample of four hundred students. Glare issues were observed in the classrooms of east-west orientation. To resolve the problem, the application of static louvers and internal blinds were suggested. A similar case was observed in Pakistani universities where a number of fans and electric lights were installed in each classroom. These appliances remained in use during the academic hours and consumed an unignorable amount of electricity. This made the assessment of students' comfort level in universities an important gap to cover.

**Thermal / Ventilation Comfort**

Climate change in regions like Europe and Asia is taking place at a very fast pace. Hence, buildings (particularly, schools, colleges, and universities) have become exposed to the effects of global variations in weather. Heracleous and Michael (2018) used simulation software to determine the risks of climate change in educational buildings. Results showed that the educational buildings are mostly incapable to deliver thermal comfort. This discomfort is severely impacting the environmental, socioeconomic interaction of users and buildings. Similarly, the buildings of Pakistani universities are usually ineffective to deliver adequate thermal comfort. In addition to the schools or departmental buildings, the universities accompany several administrative buildings; whose comfort level is also unknown. The comfortability of both, the departments and offices are crucial for better operation of the institute. Likewise, an effort was made by García et al. (2019) by conducting a comfort assessment in naturally located offices in Colombia. It involved data collection from eight randomly selected offices and seventy respondents using a seven-point Likert scale. Results showed a thermal acceptance of 96.58%.

**Acoustic Comfort**

Acoustic comfort is another important factor that significantly affects the comfortability of students in educational buildings. The absence of acoustic considerations in the planning and design of classrooms results in inaudibility in most portions of the classrooms. Thus, it should be incorporated with other comfort factors while carrying out comfort assessment surveys (Puglisi et al., 2015). It was found in the study of a high school in Italy that due to noise distortion the teacher had to put extreme vocal effort to convey the lectures in a loud and clear way. Hence, the intensity of vocal effort was found related to classroom acoustics. Several studies examined the acoustic conditions of classrooms in primary, secondary and higher secondary institutes (Buratti et al., 2018, Schneider, 2003, Winterbottom and Wilkins, 2009).

The placement of windows is very critical in increasing or decreasing acoustic comfort. Research showed that children are more impaired than adults by background sounds from the windows (Klatte et al., 2010). Other acoustic problems, like excessive reverberation, low speech levels and noisy ventilation systems were also observed in a study in United Kingdom . They also developed a five-point Likert scale questionnaire to record the opinion. and found dissatisfaction students with the acoustic quality of classrooms. Another study found intermittent background noises and an increase of intelligibility scores with the increase in reverberation (Meresi, 2016, Michael and Heracleous, 2017).

### Seating Comfort

Seating quality is a critical physical element in achieving comfortability in the classrooms. Its purpose is to support learning and ensure the provision of comfortable and less stressed environment design. One of the main negative impacts of poor seating design and quality is the bad classroom seating posture (Dianat et al., 2013). Fasulo et al. (2019) adopted a questionnaire survey with a five-point Likert scale to analyze the student's perception regarding seating comfort/discomforts. Likewise, fixed-type furniture and side-mounted chairs are usually present in classrooms of Pakistani universities They are preferred due to their cost-effectiveness (Straker et al., 2006). But it might induce constrained postures that cause muscle tension and risks health and comfort (Fasulo et al., 2019). In addition, it was found that good seating quality leads to good grades (Koskelo et al., 2007). Hence, assessing the seating comfort becomes necessary to improve students' attention and comfort level during lectures.

Several studies were found that evaluated all variables of comfort assessment simultaneously. To determine the perception of students regarding thermal, acoustic, visual and lighting comfort, Ricciardi and Buratti (2018) used a seven-and-thirteen-point Likert scale. The questionnaire survey was carried out in seven classrooms. Results portrayed the influence of illuminance on lighting comfort, the effect of glares on visual comfort and the effect of background noises on acoustic comfort. Another study in Brazil assessed the thermal, visual, acoustic and ergonomic comfort levels of the classroom and followed a similar methodology (Krüger and Zannin, 2004). In conclusion, a combined evaluation of thermal, ventilation, acoustic, lighting, visual and seating comfort emerged as the most viable option to unfold the student's perception regarding the comfortability of their educational buildings (Xue et al., 2016). Several studies on the comfort assessment of academic institutes in countries like Cyprus, Brazil, India, Greece, Iran, Italy and Colombia were found. But no such study was found in Pakistan's context. Thus, this study fills the gap by assessing the students' comfort level in universities. Moreover, for subjective measurements like student's perception, the literature suggested the adoption of a questionnaire survey based on a Likert scale. A five-point scale was found as the most preferred option in case of satisfaction studies. Also, probability sampling techniques, like simple random sampling, and systematic random sampling were found as optimum procedures to finalize the area of interest. Hence, following the footprints of the literature, the study adopted a similar methodology that is discoursed henceforth.

## RESEARCH METHODOLOGY

### Study Area

For this study, Mehran University of Engineering and Technology (MUET), Jamshoro, Sindh, Pakistan was selected as the study area (Figure 1) (MUET, 2019). It is a public research university located in district Jamshoro near Indus Highway (N-55/M-9) in Sindh province. Jamshoro falls in the hot and dry climatic region, having an average maximum temperature of 44°C and an average minimum temperature of 14°C. Most of the year, the temperature remains hot with maximum sun hours and UV index of nine validates a strong sunlight. The area receives rainfalls from June to September. Thus, comfortability in the classrooms and institutes, where students are supposed to spend twenty five percent of their daytime, becomes an important aspect to achieve.
To collect the data, two Departments, including, Department of Architecture and CRP Department were selected using simple random sampling and the respondents were selected using systematic sampling with an interval of ten (Shaharon and Jalaludin, 2012, Dianat et al., 2013, Winterbottom and Wilkins, 2009, Zomorodian et al., 2016, Korsavi et al., 2016, García et al., 2019). Being a distinguished institute, a huge influx of students enroll here annually. As each student has their own comfort requirements in the classroom, the assessment survey conducted here unfolded unique dimensions that could help the administrative bodies to make the departmental buildings more comfortable, energy-efficient and sustainable.

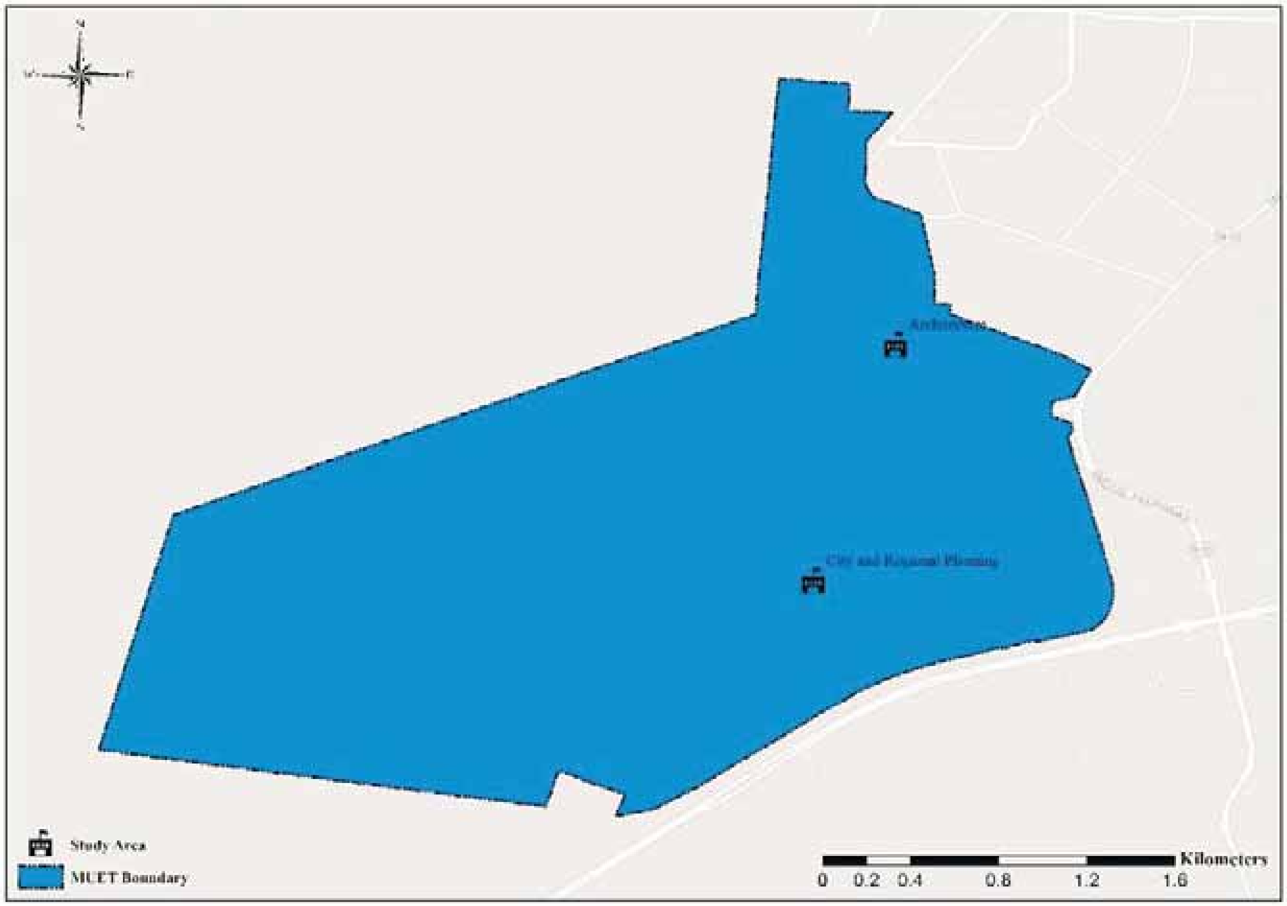


***Figure 1:*** Arial View of MUET Jamshoro

**Study Variables**

To perform a comprehensive and subjective comfort assessment survey, a combination of six variables, i.e. lighting quality, thermal quality, ventilation quality, seating quality, visual quality and acoustic quality was found in the literature. Several studies used these variables to assess the comfortability of educational buildings as illustrated in Table 1. Hence, a questionnaire comprising of questions regarding these variables was used to collect the responses of the students regarding their comfort level in the classrooms.

**Study Design**

For this study, a pilot observation was conducted in the classrooms of the two Departments. Due to the unavailability of data regarding the study, a questionnaire survey technique was opted for (Daghigh et al., 2012, Alajmi et al., 2015, Allab et al., 2016, Akande and Adebamowo, 2010, Wong and Khoo, 2003, Shaharon and Jalaludin, 2012, Andamon, 2014, Simons et al., 2014, Allab et al., 2017, Zannin and Marcon, 2007, Fasulo et al., 2019, Korsavi et al., 2016, Kumar and Singh, 2019, Shan et al., 2018, García et al., 2019). The questionnaire was divided into three sections. The first section comprised of items related to the general information about students including age, gender and department. Section two had classroom characteristics including classroom ventilation, classroom reliance on electricity and classroom performance in the absence of electricity. Lastly, section three was aimed towards recording the satisfaction level of students towards their classrooms' comfort. A five-point Likert-scale ranging from one (strongly satisfied) to five (strongly dissatisfied) assisted in capturing the responses. A questionnaire was drafted in line with the predefined variables of comfort assessment. A pilot survey was performed to validate the questionnaire and its outcome. After modification, the questionnaire survey was performed in the selected study area. For data analysis, frequency distribution and Likert-scale index score methods were used.

*Table 1:* Study Variables as Derived from the Literature Review

| Variables | Empirical Evidence |
|---|---|
| Lighting Quality | (Buratti et al., 2018, Osterreichera and Geisslerb, 2016, Holopainen et al., 2014, Lee and Schiavon, 2014, Allab et al., 2017, Pazhoohesh et al., 2015, Xue et al., 2016, Koskelo et al., 2007, Krüger and Zannin, 2004, Mishra et al., 2017, Korsavi et al., 2016, Zomorodian and Tahsildoost, 2017, Michael and Heracleous, 2017, Barbosa et al., 2020, Kumar et al., 2016, De Angelis et al., 2017, Subhashini and Thirumaran, 2018, Barbhuiya and Barbhuiya, 2013, García et al., 2019, Winterbottom and Wilkins, 2009, Ricciardi and Buratti, 2018) |
| Thermal Quality | (Krüger and Zannin, 2004, Mishra et al., 2017, Papazoglou et al., 2019, Ali and Al-Hashlamun, 2019, Simons et al., 2014, Merabtine et al., 2018, Rodriguez et al., 2019, Holopainen et al., 2014, Kumar et al., 2019, Ricciardi and Buratti, 2018, de Abreu-Harbich et al., 2018, Heracleous and Michael, 2019, Kumar and Singh, 2019, Hellwig et al., 2019, Akande and Adebamowo, 2010, Lee and Schiavon, 2014, Pazhoohesh et al., 2015, Buratti et al., 2018, Subhashini and Thirumaran, 2018, El-Darwish and El-Gendy, 2018, De Angelis et al., 2017, Astolfi and Pellerey, 2008, Barbhuiya and Barbhuiya, 2013, Güngör, 2015, Kumar et al., 2016, García et al., 2019, Alajmi et al., 2015, Shaharon and Jalaludin, 2012, Wong and Khoo, 2003, Zomorodian et al., 2016, Andamon, 2014, Allab et al., 2016, Nasrollahi et al., 2008) |
| Ventilation Quality | (Heracleous and Michael, 2018, Heracleous and Michael, 2019, Allab et al., 2016, Daghigh et al., 2012, Alajmi et al., 2015, Österreichera and Geisslerb, 2016, Akande and Adebamowo, 2010, Wong and Khoo, 2003, Simons et al., 2014, Buratti et al., 2018, Xue et al., 2016, Krüger and Zannin, 2004, Kumar et al., 2019, Kumar and Singh, 2019, Kumar et al., 2016, García et al., 2019, Barbosa et al., 2020, De Angelis et al., 2017, Merabtine et al., 2018) |
| Seating Quality | (Dianat et al., 2013, Fasulo et al., 2019, Pijls et al., 2019, Bistafa and Bradley, 2000, Mishra et al., 2017, Ricciardi and Buratti, 2018, Zomorodian and Tahsildoost, 2017, Subhashini and Thirumaran, 2018, Merabtine et al., 2018) |
| Visual Quality | (Michael and Heracleous, 2017, Buratti et al., 2018, Astolfi and Pellerey, 2008, Korsavi et al., 2016, Ricciardi and Buratti, 2018, Barbhuiya and Barbhuiya, 2013, Shan et al., 2018, Heracleous and Michael, 2018, Pijls et al., 2019) |
| Acoustic Quality | (Puglisi et al., 2015, Krüger and Zannin, 2004, Knecht et al., 2002, Ricciardi and Buratti, 2018, Sato and Bradley, 2008, Buratti et al., 2018, Zannin and Marcon, 2007, Bistafa and Bradley, 2000, Astolfi and Pellerey, 2008) |

### Sampling Plan

In order to keep the research valid and unbiased, a sample survey was carried out to collect primary data with precision and reliability. A thorough literature review was performed before selecting the sample size and optimum sampling technique. A systematic random sample was used with an interval of ten. The first student was randomly chosen in each classroom and then the questionnaire was distributed with an interval of ten (Hamdan et al., 2014). A total sample of twenty seven was selected, which was further subdivided as seventeen for the Architecture Department and ten for the CRP Department (Table 2).

## RESULTS

For a better understanding of results, this section shows the outcomes of data analysis in tabular, descriptive and graphical form. Data was firstly structured and then analyzed using frequency distribution and Likert-scale index scoring method. Fifty-four students recorded their views/opinions in the survey, i.e. no sampling error was found. As the study is focused on students' comfort, 59.2% of students were aged between 21-30 years While 40.7% aged between 16-20 years. Of the forty four respondents, 66.6% were males and 33.3% were females. Lastly, as per the decided sampling plan, 62.9% of respondents were from the Architecture Department and 37.0% were from the CRP Department (Table 3).

***Table 2:*** Sampling Plan

| S. No. | Departments | Number of Students | Sample Size (n=10) |
|---|---|---|---|
| 1. | Architecture | 166 | 17 |
| 2. | CRP | 98 | 10 |
| Total | | | 27 |

***Table 3:*** Respondent's General Information

| Student's Characteristics | | Frequency | Percentage |
|---|---|---|---|
| Age | 16-20 Year | 11 | 40.7 |
| | 21-30 Year | 16 | 59.2 |
| Gender | Male | 18 | 66.6 |
| | Female | 09 | 33.3 |
| Department | Architecture | 17 | 62.9 |
| | CRP | 10 | 37.0 |

## Classroom Characteristics

Table 4 illustrates the characteristics of the classrooms in both the Departments. Of the twenty seven students, 25.9% of the CRP department responded that their classrooms had proper ventilation. The main sources of ventilation found in the CRP Department were the doors and windows. Moreover, 37.0% of the Architecture students answered no proper ventilation in their classrooms existed. This showed that the classrooms of the Department of Architecture were not properly ventilated. 37.0% students of the CRP Department and 22.2% students of the Architecture Department responded that their classrooms relied on mechanized sources of light and ventilation. This meant that the classrooms could not function well in the absence of electricity. Thus, it was inferred that the classrooms of both the Departments were not energy efficient as they relied on mechanized sources. A partial response, i.e. 18.5% was observed from the students of the CRP Department. whereas, 33.3% of the Architecture students responded no to this question. The high negative response from the students of the Architecture Department showed that the classrooms had minimal access to natural light and air in the absence of electricity.

## Classroom Comfort Satisfaction in Perception of Students

Table 5 illustrates the students' level of satisfaction with the comfortability of the classrooms. The students of the CRP Department were strongly satisfied with the seating (+0.14) and acoustic (+0.33) quality of the classrooms. It meant that the furniture of the CRP Department was well maintained, spacious and quite comfortable. Also, the classrooms were designed by considering the classroom acoustics standards. Due to the improper orientation of the Department, excessive sunlight glares fell on the whiteboards that created visual discomfort. This discomfort increased with the rise in seating levels. Thus, students were found uncomfortable and strongly dissatisfied with the visual (-0.14) and lighting (-0.11) quality. In addition, as the classrooms remained extremely hot in summers and vice-versa, the students were found dissatisfied with the thermal (-0.11) and ventilation (-0.037) quality. This discomfort increased in the summers because extremely high temperatures were recorded in Jamshoro. Collectively, these discomforts affected the students' attention and interest in the lectures that could severely decrease the student's output.

The students of the Architecture Department were found strongly satisfied with the lighting (+0.11), acoustic (+0.14) and seating (+0.074) quality of the classrooms. The results showed that the furniture in the Architecture Department was also well maintained, spacious and comfortable. Moreover, the classrooms were designed by considering the classroom's acoustics and lighting standards. The students were however strongly dissatisfied with the visual (-0.18) and ventilation (-0.11) quality of the classrooms. Indeed, the orientation considerations were properly applied. But the classrooms were in an area having minimal access to sunlight and air. Hence, the classrooms remained dark and suffocated, that eventually created visual and ventilation discomfort. Furthermore, the thermal quality (0) of the classrooms was found satisfactory.

***Table 4:*** Classroom Characteristics

| Classroom Characteristics | Student's Perception | Architecture | | CRP | |
|---|---|---|---|---|---|
| | | Frequency | % | Frequency | % |
| Dose the classroom have proper ventilation | Yes | 7 | 25.9 | 7 | 25.9 |
| | | 10 | 37.0 | 3 | 11.1 |
| Dose the classroom rely on an electronic source of light and ventilation? | Yes | 10 | 37.0 | 6 | 22.2 |
| | | 7 | 25.9 | 4 | 14.8 |
| Dose the classroom have proper ventilation | Yes | 8 | 29.6 | 5 | 18.5 |
| | | 9 | 33.3 | 5 | 18.5 |

*Table 5:* Satisfaction Level of Students

| Department | Variables | Likert-Scale Scores | | | | | Weighed Total | Satisfaction Index |
|---|---|---|---|---|---|---|---|---|
| | | -2 | -1 | 0 | +1 | +2 | | |
| | | Strongly Dissatisfied | Dissatisfied | Satisfactory | Satisfied | Strongly Satisfied | | |
| ***CRP*** | Lighting Quality | -4 | -2 | 0 | +3 | 0 | -3 | -0.11 |
| | Thermal Quality | -4 | -3 | 0 | +4 | 0 | -3 | -0.11 |
| | Ventilation Quality | -4 | -2 | 0 | +3 | +2 | -1 | -0.037 |
| | Seating Quality | -2 | -1 | 0 | +5 | +2 | +4 | +0.14 |
| | Visual Quality | -6 | -2 | 0 | +2 | +2 | -4 | -0.14 |
| | Acoustic Quality | 0 | -1 | 0 | +4 | +6 | +9 | +0.33 |
| ***Architecture*** | Lighting Quality | -2 | -4 | 0 | +3 | +6 | +3 | +0.11 |
| | Thermal Quality | 0 | -5 | 0 | +3 | +2 | 0 | 0 |
| | Ventilation Quality | -3 | -2 | 0 | +4 | 0 | -3 | -0.11 |
| | Seating Quality | -2 | -4 | 0 | +6 | +2 | +2 | +0.074 |
| | Visual Quality | 0 | -10 | 0 | +5 | 0 | -5 | -0.18 |
| | Acoustic Quality | 0 | -6 | 0 | +6 | +4 | +4 | +0.14 |

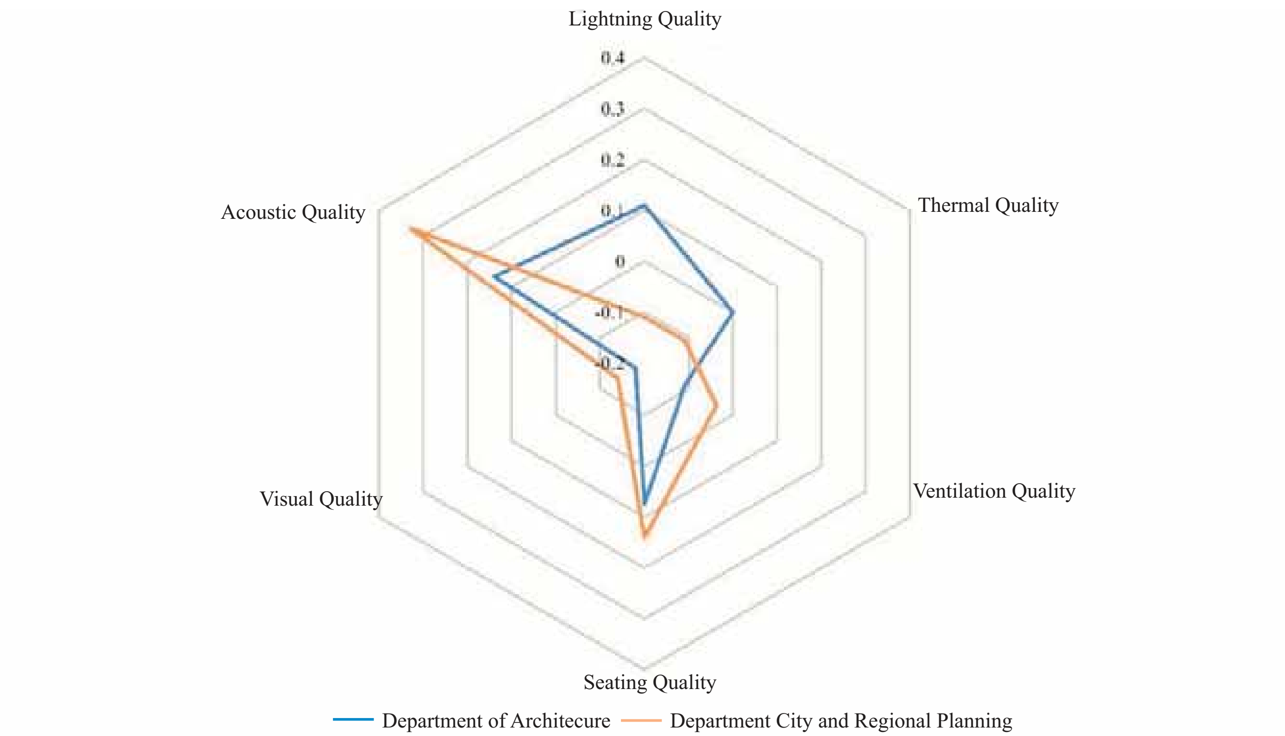


***Figure 2:*** Satisfaction Levels of the Students

## DISCUSSION

From the results, it was found that the Department of Architecture had poor ventilation as compared to the CRP Department. The classrooms of both the Departments were not found to be energy efficient because dependency on a huge number of fans and lights was required to make them comfortable. Unlike the results of Brazilian Schools, wherein noise generated and the voice of the teacher in neighbouring classrooms emerged as the root causes of acoustic discomfort, the students of both the departments were found strongly satisfied with the seating and acoustic quality as the furniture was regularly maintained and acoustic considerations were properly followed (Krüger and Zannin, 2004). The lighting quality of the classrooms of the Architecture Department was found better as compared to the classrooms of the CRP department. But both departments lacked visual comfort. Surprisingly, the students reported absence of sunlight in the classrooms of Architecture Department, whereas excess sunlight glare was reported as the cause of visual discomfort for the CRP Department. The orientation of buildings was found as the key factor behind variation in the causes of visual comfort. Compared to the CRP Department, the thermal quality of the Architecture Department was found satisfactory as the location of Architecture Department was somehow in accordance with the prevailing wind direction and sun orientation. A similar case was observed in the thermal comfort assessment conducted in the University of Pavia, Italy, wherein the influence of illuminance on lighting comfort and the effect of glare on visual comfort were found as the major causes for visual discomfort (Ricciardi and Buratti, 2018).

These findings assisted in understanding the causes of variation in the comfortability of students of both departments. This further leads to an inference that the comfortability can vary even within the buildings of an institute. Hence, the factors like thermal visual, acoustic, seating, and ventilation qualities require serious consideration during the planning and design of a building, as the efficiency and sustainability of a building relies on these factors. Thus, to make the classrooms comfortable, measures regarding these variables are needed that might positively impact on the students' interest and learning outcome. This discourse is summarized in Figure 2.

The study should also discuss its limitations. For this study, only three classroom characteristics and only six comfort assessment variables were used. Future studies could incorporate more classroom characteristics and comfort assessment variables to make the assessment more comprehensive and detailed. The aim of the study was to assess the students' comfort level in the universities of Pakistan, for which only one higher education institute and its two departmental buildings were selected. Though, the study is not representative of all educational institutes in Pakistan, yet it is a steppingstone to initiate a practice of regularly conducting thermal comfort assessment studies in all institutes to make the educational institutes energy efficient and comfortable.

## CONCLUSIONS

Considering the criticality of an indoor building environment in improving students' interest in studies, this study aimed to assess the students' comfort level in the universities of Pakistan. The study intended to quantify the satisfaction level of the students with the comfortability variables to explain the factors influencing the student's comfort the most. After collecting the data, findings were derived which had many implications. The study, therefore, found that most of the students in the CRP and Architecture Departments were facing comfort issues particularly with reference to visual, lighting and thermal quality. Whereas satisfaction with the acoustic and seating quality was observed. Hence, measures are required to improve the indoor building environments so that the students could perform their academic activities in a comfortable manner. By highlighting the areas of improvement, the study has established a baseline so that necessary measures could be taken to upgrade comfortability. Likewise, similar studies could be conducted in other universities, colleges and schools to ensure the availability of a comfortable classroom environment for the well-being of the students.

## REFERENCES


Akande O. K., and Adebamowo M. A., 2010, "Indoor Thermal Comfort for Residential Buildings in Hot-Dry Climate of Nigeria". in *Adapting to Change: New Thinking on Comfort.* Cumberland Lodge, Windsor, UK.

Alajmi, A. F., F. A., R. I., 2015, "Thermal Comfort Assessment of an Office Building Served by Under-floor Air Distribution (UFAD) System – A Case Study", *Building and Environment,* 85**:** 153-159.

Allab, Y., Kindinis, A., Causone, F., Tatti, A., Simonet, S. and Bayeul-lainé, A.-C., 2016., "Ventilation Rates and Therma Comfort Assessment in a Naturally Ventilated Classroom". *CLIMA 2016 - Proceedings of the 12th REHVA World Congress.* Aalborg University Denmark.

Allab, Y., Pellegrino, M., Guo, x., Nefzaoui, E. and Kindinis, A., 2017, "Energy and Comfort Assessment in Educational Building: Case Study in a French University Campus", *Energy and Buildings,* 143**:** 202-219.

Andamon, M. M., "Thermal Comfort Standards and Building Energy Use in Philippine Office Environments", 40th Annual Conference of the Architectural Science Association ANZAScA.

ASE. 2019, "Alliance to Save Energy (Alliance K-12)", viewed 15 October 2019 from https://ase.org/. com.

ASHRAE, 2009, ASHRAE Handbook Fundamentals 1st Edition, Atlanta, GA.

Astolfi, A. and Pellerey, F. 2008. "Subjective and Objective Assessment of Acoustical and Overall Environmental Quality in Secondary School Classrooms", *J Acoust Soc Am,* 123**:**163-73.

Bistafa, S. R. and Bradley, J. S. 2000, "Reverberation Time and Maximum Background-Noise Level for Classrooms From a Comparative Study of Speech Intelligibility Metrics", *J Acoust Soc Am,* 107**:** 861-75.

Bortolini, R. and Forcada, N. 2019, "A Probabilistic-Based Approach to Support the Comfort Performance Assessment of Existing Buildings", *Journal of Cleaner Production,* 237: 1-14

Buratti, C., Belloni, E., Merli, F. and Ricciardi, P. 2018. "A New Index Combining Thermal, Acoustic, and Visual Comfort of Moderate Environments in Temperate Climates", *Building and Environment,* 139**:**27-37.

Daghigh, R., Adam, N. M., Sahari, B. and Yousef, B. A. A. 2012, "Thermal Comfort Study and Ventilation Evaluation of an Office", *Advances in Mechanical Engineering and its Applications (AMEA),* 3:278-283.

De Abreu-Harbich, L. V., Chaves, V. L. A. and Brandstetter, M. C. G. O., 2018, "Evaluation of Strategies that Improve the Thermal Comfort and Energy Saving of a Classroom of an Institutional Building in a Tropical Climate", *Building and Environment,* 135**:**257-268.

De Angelis, E., Tagliabue, L. C., Cecconi, F. R. and Mainini, A. G. ,2017, "A Simple Method for the Comparison of Bioclimatic Design Strategies Based on Dynamic Indoor Thermal Comfort Assessment for School Buildings", *Procedia Engineering,* 180**:**870-880.

Dianat, I., Karimi, M. A., Asl Hashemi, A. and Bahrampour, S., 2013, "Classroom Furniture and Anthropometric Characteristics of Iranian High School students: Proposed Dimensions Based on Anthropometric Data," *Appl Ergon,* 44:101-8.

El-Darwish, I. I. and El-Gendy, R. A., 2018, "Post Occupancy Evaluation of Thermal Comfort in Higher Educational Buildings in a Hot Arid Climate," *Alexandria Engineering Journal,* 57**:**3167-3177.

Fasulo, L., Naddeo, A. and Cappetti, N., 2019, "A Study of Classroom Seat (dis)comfort: Relationships Between Body Movements, Center of Pressure on the Seat, and Lower Limbs' Sensations," *Appl Ergon,* 74**:**233-240.

García, A., Olivieri, F., Larrumbide, E. and Ávila, P.,2019, "Thermal Comfort Assessment in Naturally Ventilated Offices Located in a Cold Tropical Climate, Bogotá," *Building and Environment,* 158**:**237-247.

Hamdan, H., Yusof, F. and Marzukhi, M. A., 2014, "Social Capital and Quality of Life in Urban Neighborhoods High Density Housing," *Procedia - Social and Behavioral Sciences,* 153**:**169-179.

Hellwig, R. T., Teli, D., Schweiker, M., Choi, J.-H., Lee, M. C. J., Mora, R., Rawal, R., Wang, Z. and AL-Atrash, F., 2019, "A Framework for Adopting Adaptive Thermal Comfort Principles in Design and Operation of Buildings," *Energy and Buildings,* 205:1-13

Heracleous, C. and Michael, A., 2018, "Assessment of Overheating Risk and the Impact of Natural Ventilation in Educational Buildings of Southern Europe Under Current and Future Climatic Conditions," *Energy,* 165**:**1228-1239.

Klatte, M., Lachmann, T. and Meis, M., 2010, "Effects of Noise and Reverberation on Speech Perception and Listening Comprehension of Children and Adults in a Classroom-like Setting", *Noise Health*, 12**:** 270-282.

Korsavi, S. S., Zomorodian, Z. S. and Tahsildoost, M., 2016, "Visual Comfort Assessment of Daylit and Sunlit Areas: A Longitudinal Field Survey in Classrooms in Kashan, Iran," *Energy and Buildings,* 128**:** 305-318.

Koskelo, R., Vuorikari, K. and Hänninen, O., 2007, "Sitting and Standing Postures are Corrected by Adjustable Furniture with Lowered Muscle Tension in High-School Students," *Ergonomics,* 50**:**1643-1656.

Krüger, E. L. and Zannin, P. H. T., 2004, "Acoustic, Thermal and Luminous Comfort in Classrooms," *Building and Environment,* 39**:**1055-1063.

Kumar, S. and Singh, M. K., 2019, "Field Investigation on Occupant's Thermal Comfort and Preferences in Naturally Ventilated Multi-storey Hostel Buildings Over Two Seasons in India," *Building and Environment,* 163:1-29

Merabtine, A., Maalouf, C., AL Waheed Hawila, A., Martaj, N. and Polidori, G., 2018, "Building Energy Audit, Thermal Comfort, and IAQ Assessment of a School Building: A Case Study," *Building and Environment,* 145: 62-76.

Meresi, A., 2016, "Evaluating Daylight Performance of Light Shelves Combined with External Blinds in South-facing Classrooms in Athens, Greece," *Energy and Buildings,* 116**:**190-205.

Michael, A. and Heracleous, C., 2017, "Assessment of Natural Lighting Performance and Visual Comfort of Educational Architecture in Southern Europe: The case of Typical Educational School Premises in Cyprus," *Energy and Buildings,* 140**:**443-457.

MUET. 2019. *Mehran University of Engineering & Technology, Jamshoro* [Online]. viewed 8th Sep 2019, from www.muet.edu.pk

Nasrollahi, N., Knight, I. and Jones, P., 2008, "Workplace Satisfaction and Thermal Comfort in Air Conditioned Office Buildings: Findings from a Summer Survey and Field Experiments in Iran," *Indoor and Built Environment,* 17**:**69-79.

Papazoglou, E., Moustris, K. P., Nikas, K.-S. P., Nastos, P. T. and Statharas, J. C., 2019, "Assessment of Human Thermal Comfort Perception in a Non-Airconditioned School Building in Athens, Greece," *Energy Procedia,* 157**:**1343-1352.

Puglisi, G. E., Cutiva, L. C. C., Pavese, L., Castellana, A., Bona, M., Fasolis, S., Lorenzatti, V., Carullo, A., Burdorf, A., Bronuzzi, F. and Astolfi, A., 2015, "Acoustic Comfort in High-School Classrooms for Students and Teachers," *Energy Procedia,* 78**:**3096-3101.

Ricciardi, P. and Buratti, C., 2018, "Environmental Quality of University Classrooms: Subjective and Objective Evaluation of the Thermal, Acoustic, and Lighting Comfort Conditions," *Building and Environment,* 127**:**23-36.

Rodriguez, C. M., Coronado, M. C. and Medina, J. M., 2019, "Classroom-Comfort-data: A Method to Collect Comprehensive Information on Thermal Comfort in School Classrooms," *MethodsX,* 6:2698-2719.

Schneider, M., 2003, "Linking School Facility Conditions to Teacher Satisfaction and Success," viewed 22-March 2020 from http://cit.eseery.ist.psu.ed.

Shaharon, M. N. and Jalaludin, J., 2012, "Thermal Comfort Assessment-A Study Toward Workers' Satisfaction in a Low Energy Office Building", *American Journal of Applied Sciences* 9:1037-1045.

Shan, X., Melina, A. N. and Yang, E.-H., 2018, "Impact of Indoor Environmental Quality on Students' Wellbeing and Performance in Educational Building Through Life Cycle Costing Perspective," *Journal of Cleaner Production,* 204**:**298-309.

Simons, B., Koranteng, C., Adinyira, E. and Ayarkwa, J., 2014, "An Assessment of Thermal Comfort in Multi Storey Office Buildings in Ghana," *Journal of Building Construction and Planning Research,* 2**:**30-38.

Straker, L., Pollock, C. and Burgess-Limerick, R., 2006, "Excerpts from CybErg 2005 Discussion on Preliminary Guidelines for Wise Use of Computers by Children", *International Journal of Industrial Ergonomics,* 36**:**1089-1095.

Subhashini, S. and Thirumaran, K., 2018, "A Passive Design Solution to Enhance Thermal Comfort in an Educational Building in the Warm Humid Climatic Zone of Madurai," *Journal of Building Engineering,* 18**:**395-407.

Winterbottom, M. and Wilkins, A., 2009, "Lighting and Discomfort in the Classroom," *Journal of Environmental Psychology,* 29**:**63-75.

Wong, N. H. and Khoo, S. S., 2003, "Thermal Comfort in Classrooms in the Tropics," *Energy and Buildings,* 35:337–351.

Xue, P., Mak, C. M. and AI, Z. T., 2016, "A Structured Approach to Overall Environmental Satisfaction in High-Rise Residential Buildings," *Energy and Buildings,* 116**:**181-189.

Zannin, P. H. and Marcon, C. R., 2007, "Objective and Subjective Evaluation of the Acoustic Comfort in Classrooms," *Appl Ergon,* 38**:**675-80.

Zomorodian, Z. S. and Tahsildoost, M., 2017, "Assessment of Window Performance in Classrooms by Long Term Spatial Comfort Metrics," *Energy and Buildings,* 134**:**80-93.

Zomorodian, Z. S., Tahsildoost, M. and Hafezi, M., 2016, "Thermal Comfort in Educational Buildings: A Review Article," *Renewable and Sustainable Energy Reviews,* 59**:**895-906.