# The Construct of Comfort: A Case Study of Environmental Comfort of University Classrooms

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***Abstract-*** A large number of students spend more time at school than they do at home. This indicates the need to have comfortable spaces in educational buildings. The quality of an Indoor environment is directly related to students' productivity and well-being, but recent researches mainly focus on the effects of single parameters on human comfort, without examining the other variables, such as thermal, acoustic, and visual. This paper studies the indoor comfort level of university classroms. The objective of this research is investigate the quality of the school environment in relation to comfort by analyzing all the factors (thermal, acoustic, lighting, air quality) which affects the users' wellbeing. Researches have shown that the thermal, acoustical, visual quality in classrooms plays a significant role to students' behaviour and performance. In order to optimize the students' performance in clasrooms, all these variables need to be fully studied and considered. Past literature reviews studying the issue of indoor environmental quality and its comfort, mainly focused on the effects of a single factor. For instance, reviews have been conducted to study the conditions that lead to occupants' satisfaction with the thermal environment or with the acoustic environment. There has been little or no review conducted to summarize the possible effects of different factors, thermal, visual and acoustic conditions as well as indoor air quality on indoor environmental quality. The present literature review was performed to gather more information on this matter. Therefore, this paper focuses on thermal, acoustic, lighting comfort, as significant factors that may have an effect on the students' performance, with regards to attention, comprehension and learning levels.

***Keywords-*** Thermal comfort, Acoustic, Lighting, University Classrooms, Construct, Air Quality, Indoor Environmental Quality

## INTRODUCTION

A comfortable microclimatic condition is vital for all types of environment especially schools, as they are a category of buildings where a high level of environmental quality may considerably enhance users' concentration, learning, attention, understanding, hearing and performances. Buildings protect people from the outdoor conditions especially extreme temperatures, wind, rain and noise. The main aim of a space is to create an indoor environment in which users feel comfortable. Lack of good environmental comfort can greatly influence the learning capacity of students. Several studies show that a comfortable environment enhances productivity for workers and the same can be said for students as well. University classroom is an indoor space that's used by students during the day as well as at night. Therefore, the students' expectations of comfort in the studios should be researched to determine alternative means for optimizing performance. Since the classroom is a highly populated space, providing a comfortable environment has always been a critical issue. Environmental comfort consists of three various research areas: thermal, acoustic and luminous comfort. Thermal comfort is defined as "that condition of mind, which expresses satisfaction with the thermal environment" (ISO Standard 7730 in 1994). When a user feels thermally comfortable, the user will not want to be warmer or colder if asked about thermal state at that time. In recent years, thermal comfort has been examined as an important factor that's related to wellbeing and productivity of building occupants. Thermal comfort is one of the most studied terms in relation to phenomenology in Architecture as it is an important factor that affects students' performance. How comfortable users feel in a space is directly related to the meaning they attach to that space. Around the middle of 1950, the very first research on how the thermal environment affects students' performances was conducted. Studying thermal comfort in different locations enables us to ascertain the acceptable range of environmental parameters. This permits to propose some architectural recommendations and to determine building materials best adapted to each type of climate (Jannot, 1993). Classrooms that are thermally uncomfortable due to being overheated or too cold can in turn lead to physical stress (thermal stress) and are therefore responsible for illnesses and poor performance of the students. Learning involves verbal communication between teachers and students and among students. The efficiency of this communication is measured by the acoustic conditions of the

classrooms. A good acoustic condition is one of the vital factors needed to carryout different class activities, especially those that require a high level of concentration. The quality of sound in an environment is connected to various physical variables, which consists of both the physical properties of the space and sound itself. The acoustic environment is affected by the physical characteristics of the space such as sound insulation, absorption and reverberation time. It is essential to have a good acoustical condition in classrooms especially since reverberation or excessive background noise obstructs communication, causing an acoustical barrier to learning. A classroom with poor acoustic comfort leads to lack of proper comprehension and understanding by the students and also affects the physical stress of the teacher. Visual comfort is defined as "a subjective condition of visual well-being induced by the visual environment" (BS 2011) Visual comfort as well is an important requirement to be ensured in classrooms. It is a crucial factor for learning and it is recognized to enhance the educational process. Visual conditions are characterized by such parameters as luminance distribution, illuminance and its uniformity, glare, colour of light, colour rendering, flicker rate and amount of daylight (CEN 2002). The way the classrooms are perceived by students is actually directly related to their concentration. Learning and studying is easier if there is a suitable light level. Perception of an environment by the user the way it appears (the "luminous ambient) is directly connected to the users' ability to stay concentrated over class or study time: learning is less difficult if the light over the desks' surface is adequate. Insufficient lighting affects student's performance and attention span. The adequate use of daylight can stimulate energy conservation and also create a comfortable environment for both learning and teaching activities.

## LITERATURE REVIEW

Urbanization has a great influence on the local climate of an area. This micro-climate change may affect the surrounding environment, including schools (Puteh & Ibrahim 2012). Yet, the study of comfort in schools is very limited. The study of comforts determines how we view it. Almost any explicit model will entail recognition of comfort as a construct, not measurable per se, but seen through manifestations (Cain 2002). Thermal comfort as defined in the ISO 7730 standard (1994), as being "that condition of mind, which expresses satisfaction with the thermal environment". A definition most people can agree on, but also a definition that is not easily converted into physical parameter (Olesen, 2000). Human occupants are more sensitive to the variation of temperature rather than relative humidity (Hussein et al., 2002). A lot of Research carried out by Researchers such as Agung Murti Nugroho (2011), Hussein and Rahman (2009) and Wafi and Ismail (2010) explain that thermal comfort has an effect on its occupancy. In the 20th century, with widespread adoption of central heating and air conditioning in the U.S.A., it became routine for institutional and commercial buildings, e.g., schools, to provide an approximation to general comfort (Cain 2002). This signifies that users could perform well without involuntary stress from feeling too cold or too warm, from unwanted noise, from unwanted odors, or from having irritated eyes, nose, or throat. These aspects of comfort are classified under the central control. Indeed, research indicated that students' achievements are higher in those environments which students feel comfortable and positive in (Waldrip & Fisher 2003). The learning environment has an effect on the mental health of the students, thus a comfortable environment lays a good foundation for them to harness their mental capacity. Students 'awareness of this environment is crucial when it comes to their learning capability. The human's reaction towards the tolerance of higher temperature depends on his expectations, personality and his work at that particular time (Mclntyre, 1980). Therefore, one of the main design criteria for designing a good studio space is an appropriate temperature and humidity control that responds to the students and staff sensitivity. Environmental comfort can be linked to functionality of a space as well the thermal, acoustic and lighting conditions. Unfavorable conditions of comfort in schools—such as high temperatures, excessive noise, inadequate illumination, high occupation density in the classroom, and inadequate equipment in relation to age groups—can have negative influences on students' school performance and can cause health problems (Kowaltowski et al., 2001). A comfortable learning environment which fulfills needs of students helps to facilitate active learning, and in turn enhances their ideal understanding. Therefore, it is recommended that systemized evaluation of the learning environments in relation to thermal, acoustic and lighting conditions of the classroom is regarded as essential because the data collected can be used as a foundation to enhance the standard and effectiveness of teaching and learning in the classrooms. Thermal comfort is vital for every environment, but a teaching environment requires high so as to guarantee good health and comfort for users. When thermal comfort and excellent IAQ conditions are provided inside an environment, a sense of general well-being can be felt by people: this can lead to appreciable advantages on student productivity and on their attention

(Clements-Croome 2000). Such aspects are very important because students have to spend lots of time in listening and understanding lessons.

In relation to comfort, one of its construct is acoustic. Acoustic comfort is one of the key aspects for the advancement of class activities, specifically those that need a high level of concentration and participation. Good acoustics is an indispensable requirement for verbal learning and therefore vital to all knowledge-based societies (Karabiber and Vallet, 2003). Poor acoustic design of classroom spaces affects both the understanding by the students and the physical stress of the teacher. The acoustic condition in classroom has become a worldwide topic to study. Background noise is one of the parameters that affect the acoustical comfort of classrooms (Zannin 2007). When a classroom has good acoustics, teaching would become more effectual and less taxing, more verbal interaction and less repetition of word or subjects: hence teaching and learning would be less difficult and less stressful. Lighting in teaching environment is also important for both students and teachers. Visual comfort in classrooms has been reported, to be a crucial factor for learning and it is recognized to enhance the educational process.

## METHODOLOGY

A literature search for articles discussing the results of studies on how thermal, acoustic and visual comfort are perceived by occupants' with regards to the overall satisfaction with the indoor environmental quality (IEQ) and the effects it has on human comfort. The search was carried out only on articles that examine educational buildings especially the university. Relevant articles on the subject were electronically searched in the databases of Science Direct, Compendex and Web of Science. The data collected in these articles created through different studies from case studies, questionnaires, literature reviews, and field and laboratory studies. Articles examining how thermal, acoustic and visual comfort affects occupants' were searched using keywords that are connected to indoor environment quality. More than 10 articles were examined, articles that presented information related to the above subject. Among these articles, about seven were published from 1990 to 2009. The rest of the articles were published later than 1990. These articles studied the significance of at least three environmental factors affecting human comfort. The literature that give valuable data on factors which are not related to the indoor environment but have an effect on how comfortable it is was searched using keywords describing occupant perception, subjective response, human/personal factors and building factors. Articles were also chosen on the basis of whether they contained enough data to determine how these variables have an effect on occupants' comfort.

## FINDINGS AND DISCUSSION

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has a detailed standard for thermal comfort (ASHRAE 55-1992): "The purpose of this standard is to specify the combinations of indoor space environment and personal factors that will produce thermal environmental conditions acceptable to 80% or more of the occupants within a space" (p. 3). Most of the reviewed papers used quantitative models and qualitative assessments to evaluate the significance of various environmental factors for overall satisfaction with Indoor Environmental Quality. The human's reaction towards the tolerance of higher temperature depends on his expectations, personality and his work at that particular time (Mclntyre, 1980). The alteration in thermal and acoustic conditions and air quality should be different in order to obtain the same alterations with the general satisfaction of the Indoor Environmental Quality. Reviewed studies examined the importance of environmental conditions through subjective evaluations of the occupants. Only those environmental factors considered important by building users are classified by qualitative assessments. Further information was given by quantitative models as they demonstrated the degree to which the environmental conditions should be changed to establish an improvement in comfort. These papers investigated the value of indoor environmental conditions for comfort by questioning the students to rate the conditions according to their importance or to fill questionnaires showing their satisfaction with different environmental conditions or overall satisfaction with Indoor Environmental Quality; the results were used to determine the contribution of satisfaction with each parameter to overall satisfaction with Indoor Environmental Quality. The responses of these studies indicates that thermal comfort was ranked to be a little bit more important than acoustic comfort and satisfaction with air quality was a little bit more important than visual comfort. Also, some studies showed that the level of satisfaction affected the rating of the condition, when people were dissatisfied with a situation, this condition was deemed more important. With regards to whether thermal comfort is influenced by the outdoor climate and season, some studies show that users staying indoors felt warmer in winter than in summer even though the indoor temperature was. It was steadily observed that neutral and comfort indoor temperatures increased with increasing outdoor

temperatures. Colder climates had lower comfort in compared to warmer climates.

## CONCLUSION

This paper presents the examination of university classrooms in relation with thermal, acoustic, and visual comfort. The effect of these factors on the success in education is a major new finding for study in schools. The importance of the study of thermal comfort is linked to the relationship between the comfort of the occupants in the built environment, the building's functionality, and energy consumption. Since, students spend a lot of their time in classrooms, providing good thermal comfort and also indoor air quality is important. In educational buildings, thermal discomfort can create unsatisfactory conditions for both teachers and students. Designing buildings to make learning easier and to overcome discomfort is the main challenge. Future classrooms need to be designed using green design principles such as (shape, orientation, lighting, high window-to-wall ratios, high room heights, mounting ceilings, etc.) to ensure that spaces are comfortable to promote health and encourage learning. Teachers and students are the beneficiaries of good environmental conditions in schools, with special attention given to individuals with hearing, visual, speech, attention or learning disabilities. University classrooms need adequate control of temperature and humidity which responds to the sensitivity of the students and staff. The continued stress caused by the environment can drain the physical and mental abilities of the student that have an effect on their efficiency. In order to achieve good thermal comfort, exposed surfaces should be protected by vegetation, shades and fins in order to reduce indoor temperature, as the rise in air temperature leads discomfort and in turn affects the students ' performance. The classroom comfort levels can be increased with good air ventilation systems either naturally or mechanically. Several design guidelines to enhance indoor thermal comfort along with passive techniques can be implemented with the use building materials. Building a comfortable thermal atmosphere is often considered as the most vital factor in obtaining overall satisfaction with the quality of the indoor environment. Providing users with the means to regulate the indoor environment enhances thermal and visual comfort and overall Indoor Environmental Quality as well as indoor air quality satisfaction. Reviewed papers have shown that students tend to enjoy cooler climates and are more sensitive to warm weather. The creation of spatial and temporal thermal comfort metrics could be useful for design assessments, especially in classrooms where students have to sit in a fixed position during class time.

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