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The Level of Indoor Thermal Comfort in Malaysian Student Residential College

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Abstract: Higher education institutions (HEI) are the centre of learning and teaching that are responsible for producing high-quality first-generation. The inadequate number of student accommodations also resulted in stacking several students in one room, leading to discomfort, space constraints, lack of privacy, and other health conditions. This study investigates the level of indoor thermal comfort on occupant living at student residential college, which was built by the private party without complying with the design elements that have been gazette by Malaysian building standard. Besides that, the relationship between the room orientation designs in influencing student comfort level will also be inspected. The method consisted of distributing a questionnaire to the occupants and measuring operative air temperature. The study results found that the respondents have a high level of dependence on the mechanical ventilation system, namely the fan, due to the higher temperature and lack of airflow elements. This study also shows a positive relationship between the room orientation designs affecting the level of comfort of the occupants, supported by a correlation analysis. High average temperature occurs at the peak hour (noon) recorded at 31°C, which is above the recommended standard temperature listed by the Department of Standard Malaysia. This study help increase the knowledge of indoor thermal comfort throughout the design phase that can maximize the occupant's wellbeing and productivity.

Keywords: Higher Education Institutions (HEI), thermal, comfort, student residential college

1. Introduction

Higher education institution (HEI) is one of the most critical institutions in Malaysia. The booming numbers of student enrolment in public universities have resulted in the growing demands of student accommodation throughout the region. The increasing number of students enrolled in HEI is not commensurate with the university's facilities such as the limited accommodation centre available to meet the demands of students registered at the university (Muslim, *et al.,* 2012; Najib *et al.,* 2011). Moreover, the accommodation demands are unable to be granted by the government as the limited government resources concerns. This scenario has attracted the attention of private sectors that are more profit-oriented parties to invest in developing student residential colleges to meet the students' demand (Nimako & Bondinuba, 2019). However, this trend has been affecting the occupants' thermal comfort as the design and climate elements consideration were neglected throughout the entire process of the student's residential college development, resulting to a higher temperature within the room. Besides that, the inadequate number of student accommodation also resulted in stacking several students in one room that will cause discomfort, space constraints, lack of privacy, insecurity, and other health condition such as asthma, dizziness, and fatigue (Gou *et al.,* 2018; Najib *et al.,* 2011). The construction of a student

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residential college should be planned in detail so that each space can be used as best as possible and can provide active functions to its users (Buyung & Shafii, 2014). Besides that, the lack of student residential planning and development knowledge among the construction parties has a more significant impact on the building elements in the future such as the disturbance of students' well-being while living in the dormitories. The shortage of specified design guidelines in Malaysia regarding student residential development will lead to an unbalanced environment circle among students and the wastage of resources due to differences in design weaknesses (Shamsuddin *et al.,* 2007).

Buildings play essential roles as a shelter to protect occupants from the unpredictable weather. A good building's characteristics are buildings that can protect the occupants from the pressure of climate changes from the surroundings. Facilities that can function actively towards heat changes will provide comfort to the occupants of the buildings (Almansuri *et al.,* 2009). Buildings that are unresponsive to climate change will trigger heat stress in the buildings and can be detrimental to occupants' health (Olanipekun *et al.,* 2017; Raja *et al.,* 2001). Higher education institutions (HEI) are the centre of learning and teaching responsible for producing high-quality generation who can contribute to future economic development and industrial development (Noor, 2014). The issue of thermal comfort in student residential colleges should be addressed as the satisfaction towards the living environment in a residential college will affect the student's learning process (Puangmalee *et al.,* 2015).

Thermal comfort is the state of mind where it is closely related to individual subjective preferences influenced by the physical and psychological factors that occur within their range of environment (ASHRAE Standard 55, 2004). The indoor thermal comfort in HEI residential college plays a vital role in the student's learning process (Puangmalee *et al.,* 2015). The private sector's failure in designing a residential building that is capable of interacting positively with the climate elements such as wind, solar gain, humidity, and so on will lead to indoor thermal discomfort and the increasing amount of energy demand and usage (O. K. Akande, 2010).

Thermal comfort is a critical aspect of the development process in this era. Thermal comfort is an individual's assessment of a situation in which the subconscious mind serves as a tool that expresses individual satisfaction. The leading cause that affects the level of thermal comfort depends on the environmental characteristics of the term itself, which influences the heat exchange between the human body and the environment (Hoof, 2010). Thus, thermal comfort is subjective.

Indoor thermal comfort is the level of comfort of the occupants in a home. The probability of a user achieving an adequate level of internal thermal comfort is difficult because the term's nature is too subjective to measure. The main element that plays a role in providing high internal comfort to the occupants in it is the physical characteristics of the interior space of the house, the types of openings that can give freedom to airflow to and from into space efficiently, the environment of the residential area such as landscape shading area and many more (Al-Tamimi *et al.,* 2011; Amasuomo & Amasuomo, 2016; Bhikhoo *et al.,* 2017; Jamaludin & Hussein, 2012). The concept of indoor thermal comfort is closely related to the change of temperature pattern in the room such as overheat which will cause adverse effects on daily human life such as low productivity, fatigue, and more (O. K. Akande, 2010). In this context, students living in student dormitories should not be excluded as the heat stress in the dormitory building will cause discomfort and interfere with student learning performance. Malaysia has a hot and humid climate with temperatures ranging from 20°C to 32°C during the day while at night it recorded a relative humidity of around 75%, while the optimum temperature to achieve indoor thermal comfort in the student dormitory building is 28.8°C (Dahlan *et al.,* 2009). This proves that air temperature is a significant factor in the deterioration of students' indoor thermal comfort residing in student dormitories.

This study mainly identified the level of indoor thermal comfort of students living in student accommodation built by the private party without complying with the design elements that have been gazetted by the Malaysian building standard, “Bangunan Perancangan Jawatankuasa Standard dan Kos”. Besides that, the relationship between the room designs in influencing student comfort level will also be inspected.

2. Literature Review

Passive buildings are design alternatives that practice and utilize the surrounding natural elements such as wind, heat and solar energy sources to develop smart buildings that rely on architectural design (Ochoa & Capeluto, 2008). According to Day & Gunderson (2015), passive building methods can benefit consumers and the environment. This is due to the nature of passive buildings specially designed to reduce energy consumption in a building and achieve environmental quality for human benefit. Table 1 shows some of the passive building strategies applied in every building in Malaysia.

Table 1 - Passive building characteristics

Building Elements	Description

Building Orientation	An east-oriented house has cooler indoor temperatures than a western-oriented home that receives sunlight in the afternoon. Although the north-facing room is cooler, it is not optional, as it gets minimum sunlight (Mallick, 1996). Akande & Adebamowo (2010), also asserts that buildings in the western part are more prone to heat in the afternoon. Therefore, the part of the west is more suitable to place the bedrooms because the bedroom will only be used at dusk after the occupants return from doing their daily activities.
Natural Ventilation	Sufficient natural ventilation allows the air inside the house to move from one point to another, even in a closed environment. Indoor air quality in residential units that rely on mechanical and air-conditioned ventilation has higher carbon dioxide (CO_2) than those using natural ventilation (Akande, 2010). Therefore, the design of buildings that emphasize the elements of natural ventilation will improve occupants' health status and contribute to sustainable development, improve environmental air quality and energy-saving.
Natural Lighting	The natural lighting system's effectiveness depends on several factors such as the position of the building, the surrounding climate, the physicality of the building, and the lighting needs in a space. The use of low natural lighting is believed to reduce electricity consumption while reducing energy demand for cooling needs resulting from the internal load from artificial lighting (Jamaludin *et al.,* 2015).
Solar Protection	The functional building design able to provide solar protection that can reduce radiation exposure directly to humans. This strategy is to create shading effect by opening orientation to the north or south to maximize shading when the sun is at its peak (Bhikhoo *et al.,* 2017).
Room Layout	The layout in a residential unit plays an essential role in ensuring airflow to all corners of the space in a house. This is critical to ensure the presence of wind at each main point of each space to provide maximum comfort to occupants without additional assistance from mechanical ventilation such as fans to ensure uniform air flow (Bhikhoo *et al.,* 2017).
Building Envelope	The exterior of a building enters a building through the roof, walls, windows and doors. Sustainable air retention on the outside of a building is vital in the residential environment to ensure fresh air sustainability that can be easily renewed without the need for assistance from any mechanical system. This is to increase the level of indoor comfort and performance of the building (Gou *et al.,* 2018).

3. Methodology

This study only focuses on indoor thermal comfort levels in the student residential area. This study was held in one of the residential colleges at Universiti Tun Hussein Onn Malaysia (UTHM) namely Kolej Kediaman Perwira, built by the private sector and rented by UTHM to be used as students residential college due to the lack of students accommodation provided by the university. This study also consists of determining the degree of air temperature that influences the thermal comfort environment. Besides that, a questionnaire survey was also conducted in the same residential area (Figure 1).

Fig. 1 - Building layout

Several phases of research methodology have been involved in this case study, such as site measurement and distributing a questionnaire survey to the occupants:

3.1 Questionnaire Distribution

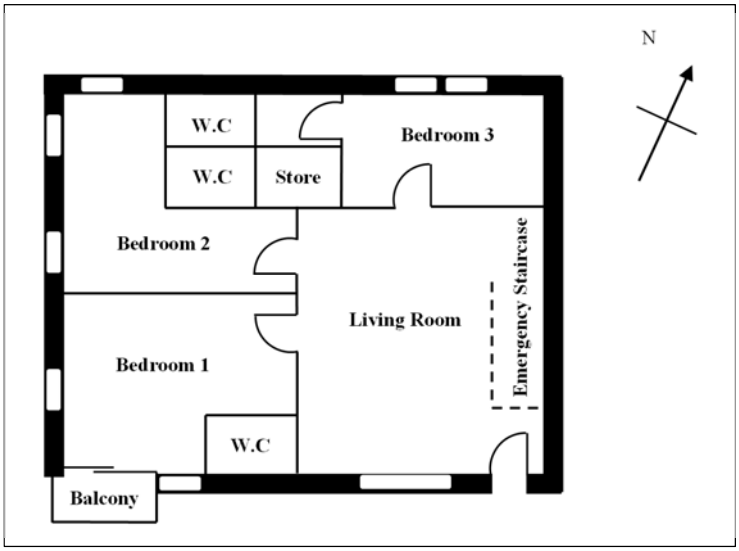
The questionnaire was distributed among the residents of the residential college using face to face method. The questionnaire was prepared in Bahasa Malaysia and consists of four parts which include the respondent's background, current satisfaction towards thermal comfort in their room and room design in a residential college. The Likert scale method is thoroughly used in this questionnaire section, and respondents are obligated to rate their thermal sensation judgment throughout living at the residential college. The respondent sampling size was determined by referring to the Krejcie and Morgan's table to select the respondents' reliable numbers.

3.2 Indoor Thermal Comfort Measurement

The site measurement was conducted to observe the air temperature using 4 in 1-meter kit tools. The measurement was taken in their operative surroundings, which means the data were collected when the occupants were in the room. This action ensured the heat production from the occupant's body was taken into consideration to manage the actual data of the comfortable temperature in the case area. Each measurement was conducted where the tool was stationed at a standard height of one foot above the floor level to avoid any future problems. The measurement was taken four times a day (morning, noon, evening, night).

The measurement location was taken at three blocks available in the residential college, which is block L, block M and block N. These blocks selected due to the room orientation factors in terms of space, design, and environment that differ from one block to another. This study was conducted at three rooms of different levels and blocks: the lowest level, the middle level, and the top level. Room L4-01(Block L) was located on the left side of the building. This room has three rooms, three bathrooms in each room, storage and an emergency staircase. This room on the fourth Floor accommodates five post-graduate female students possess an excess to additional space such as storage stores and balconies that are not available on other levels (Figure 2 (a)).

Meanwhile, nine female students accommodate room M2-05 (Block M). The minimum number of windows with a large number of room members contributes to discomfort. This room was protected from direct sunlight as the tall buildings and trees public in the area (Figure 2 (b). The third temperature measurement location was conducted in room N1-03 (Block N). The room is located in the middle of the building. This room has a living room, kitchen, three rooms and three bathrooms in each room. The room on the ground floor also has the advantage as it was protected from direct sunlight. The selection of different locations identifies the temperature difference in each room based on the design and other factors such as building orientation and room exposure to sunlight (Figure 2 (c)).



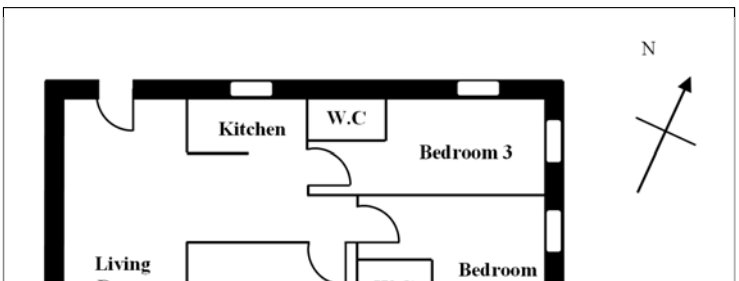


Fig. 2 - (a) building floor plan block L (2nd floor); (b) building floor plan block M (2nd floor); (c) building floor plan block N (ground floor)

3.3 Data Processing Process Indoor

Data that have been obtained by the study were analyzed using the Statistical Package for Social Science (SPSS). The analysis phases applied in this study to finalize the outcome are the normality test method and correlation method. Normality tests are essential to identify whether the data are normally distributed or otherwise. Kolmogorov-Smirnova method is the best method to conduct a normality test for this study involving the number of respondents over 50 people. The sample distribution pattern determines the appropriate correlation method to analyze the survey at the next level. Through normality tests that have been conducted, it has produced normal data distribution, and the Pearson Product-Moment correlation test was used for this study. Through the classification from Alpha Cronbach, the relationship between the variables is determined using the value of the correlation range ranging from -1.00 to +1.00 which means that the higher the correlation value (r), the higher the relationship or correlation between the two variables that are interdependent with each other.

4. Results and Discussion

a. The General Data

The total numbers of test subjects were 66 respondents which are 42 females and 24 males. The result shows patterns, where the majority of respondents responded to the questionnaire are the students that have stayed at the residential college for more than four semesters which is a total of 31 people followed by students that have lasted for two semesters (20 people), one semester (10 people) and three semesters (5 people).