



INDOOR THERMAL COMFORT IN UNIVERSITY CLASSROOM: A CASE OF UNIVERSITI TEKNOLOGI MALAYSIA

Zuhairah Zuhari, Low Sheau-Ting*

Department of Real Estate, Faculty of Built Environment and Surveying
Universiti Teknologi Malaysia, Skudai, Johor, Malaysia

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*Corresponding Author
sheauting@utm.my

ABSTRACT

The student spends the majority of their time in the classroom to participate in the learning and teaching session. Recently, there are plenty of issues reported from the building occupants due to poor thermal comfort in the building. A poor indoor thermal could lead to Sick Building Syndrome (SBS), unproductive and unhappy occupants. A conducive indoor thermal environment, on the other hand, helps the occupants to perform well, such as increasing their ability to focus, become more productive and not easily get an illness. This study aims to investigate the indoor thermal comfort level of classrooms in a university. Empirical data were collected from field observation which was held in two sessions (morning and evening) in February 2019 in 40 classrooms. The results showed that 70 % of the classrooms have complied with the existing standard of air temperature and 85 % of the classrooms have complied with the standard of relative humidity. All of the classrooms were recorded with a higher level of air velocity as required in the standard. The findings of this study can provide a guide for facilities manager to improve the indoor thermal comfort level in the classroom and increase awareness among building users on the importance of conducive indoor thermal comfort.

1.0 INTRODUCTION

Indoor Environment Quality (IEQ) is an important criterion for assessing indoor environment performance in a building. The assessment of IEQ is important to express the indoor condition of a building, either the indoor condition is safe or harmful for the occupants. The growing attention on this issue is due to the increasing number of cases reported on health problems, and discomfort among building occupants since most of them are spending 90% of their time indoors (Mallawaarachchi, De Silva and Rameezdeen, 2017; IWBI, 2019). The condition of the indoor environment has a direct impact to its occupants. As mentioned by

Environmental Protection Agency (2014), human exposure to indoor pollution is two to five times higher compared to outdoors. Therefore, IEQ assessment should be conducted to enhance the indoor environment quality by ensuring that the IEQ elements are complied with the standard (Kamaruzzaman *et al.*, 2016).

An assessment of IEQ performance in Malaysia should emphasis on thermal comfort by considering the climate condition in Malaysia, which classified as hot and humid. This climate may affect the indoor thermal comfort and cause dissatisfaction and unhappiness among occupants such as they might feel discomfort, hence impact on their productivity (Kamaruzzaman and Mohd Tazilan, 2013). Additionally, the assessment of

thermal comfort should be given serious attention due to the several numbers of complaints on poor performance of IEQ in the building. For example, the Environmental Protection Agency (2014) claims that thermal comfort is one of the parameters that contribute to a massive impact on indoor contaminant levels.

A poor indoor thermal comfort in a house contribute to the high demand of electric energy for cooling purposes, then extended an effort towards a sustainable town. Next, a different study conducted in office building context stated the same issues, which poor thermal comfort causes health issues and decrease their productivity and performance (Ali, Chua and Lim, 2018). The health problems including fever, tiredness and difficult to concentrate. Also, a study by Wan Yusoff *and* Sulaiman (2014) stated that poor quality of indoor environment including a poor thermal comfort in the classroom could cause discomfort to the building occupants which may lead to the Sick Building Syndrome (SBS) symptoms. According to World Health Organization Committee, SBS is a symptom experienced by building occupants such as throat irritation, headache, dry or itchy skin which primarily caused by the poor quality of the indoor environment in the building.

Serious attention should be given on thermal comfort assessment in an academic building as student spend the majority of their time in the classroom (Singh, 2018). Indoor thermal in the classroom quality play an important role in influencing the student's performance and well-being (Singh *et al.*, 2019). However, the study on thermal comfort level in the academic building is still limited and not being concerned as top priority (Puteh *et al.*, 2012). There is one study conducted in the university context by Wan Yusoff *and* Sulaiman (2014) indicated that thermal comfort level in UTM was not complied with the recommended level as stated in MS 1525:2014. Nevertheless, the evidence of the study cannot be considered as comprehensive to define the thermal comfort in UTM's classroom as a limited sample has been used (five classrooms). Therefore, this study aims to investigate the level of indoor thermal comfort in UTM's classroom by using a large number of samples for greater representativeness. The measurement of indoor thermal comfort will be

assessed using appropriate instruments; then the reading will be recorded. The following sections describe the concept of thermal comfort, the related standard, the flow of research methodology, the results, discussion and finally a conclusion.

2.0 INDOOR THERMAL COMFORT

ISO Standard 7730:2005 define thermal comfort as "the condition of mind, which expresses satisfaction with the thermal environment". Thermal comfort is a subjective feeling that differs for each people as it based on their perception and preference on a particular indoor thermal environment. Therefore, it is relatively difficult to achieve a standardize comfortable indoor thermal environment for all building occupants. However, as indicated by ASHRAE, the thermal environment is acceptable when 80% of the building occupants are satisfied and comfortable with the indoor thermal environment in a building.

Indoor thermal comfort can be assessed by parameters which categorized into two categories, namely environment factor and personal factor. The environment factor consists of air temperature, relative humidity, air velocity and mean radiant temperature. Meanwhile, personal factors include the metabolic rate (activities) and clothing insulation (ASHRAE 55-2010). According to Ahmad and Ping (2015), the temperature is the average measure of the kinetic energy of the molecule in the system object and can be measured by a thermometer or calorimeter. High outdoor temperature gives a significant impact to the indoor air temperature, hence contribute to low occupants' thermal comfort level. Humidity is the level of water vapour in the air. In detail, water vapour is a state of invisible water and gas.

This study will only cover three thermal environment parameters, namely air temperature, relative humidity and air velocity. It is highlighted that the adopted three parameters is sufficient in determine indoor thermal comfort. This is because there are several previous studies have focused on the three or less parameters to investigate the indoor thermal comfort performance in an academic building (Ahmad *and* Ping, 2015; Ahmad *and* Hassim, 2015; Arifin

and Denan, 2015; Djamila, Chu and Kumaresan, 2013; Jamaludin, Mohammed, Khamidi and Wahab, 2015; Kamaruzzaman *et al.*, 2016; Kaźmierczak *et al.*, 2018; Lee *et al.*, 2017; Malek, Khairuddin, and Rosli, 2015; Wan Yusoff and Sulaiman, 2014).

For instance, a recent study by Kaźmierczak *et al.* (2018) has adopted air temperature and relative humidity in order to justify indoor thermal comfort in the university's classrooms. The findings show that the recorded air temperature is too high and the relative humidity is too low. However, the majority of the occupants claim that indoor thermal comfort is acceptable. Another study by Kamaruzzaman *et al.* (2016), adopted all the three parameters in conducting of indoor thermal comfort in an academic building. Overall, the findings reveal that the air temperature and relative humidity is beyond the standard, while air velocity is stale but considered as low. Moreover, a study conducted by Ahmad and Hassim (2015) in academic building has revealed that the air temperature above the standard set, relative humidity within the standard set and air velocity is below the standard set.

3.0 MALAYSIAN STANDARD OF THERMAL COMFORT: MS 1525:2014

The standard of thermal comfort assessment adopted in Malaysia is known as MS 1525:2014, second edition. The first edition of the standard has been introduced and enforced since 2007. The purpose of this standard is to create a conducive and environmentally friendly indoor environment. Besides, this standard provides a benchmark to determine the appropriate thermal comfort for non-residential buildings, including an academic building.

This standard was created by the Department of Standard Malaysia by adopting and localize the international standards which is ASHRAE 55-2010. Usually, ASHRAE will be referred in evaluating thermal comfort in North America. There are some differences with the recommended indoor thermal comfort's level between the two standards. The level of thermal comfort as stated in ASHRAE and MS 1525:2014 is shown in Table 1. It is highlighted that this

study will comply with this standard to define level of indoor thermal comfort in UTM's classrooms. The level of air temperature will be measured in Degree Celsius (°C), relative humidity in percentage (%) and air velocity in meter per second (m/s).

Table 1. The recommended level of indoor thermal comfort according to ASHRAE 55-2010 and MS1525:2014.

Parameters	ASHRAE	MS 1525:2014
Air Temperature	23°C -26°C	24°C – 26°C
Relative humidity	30% - 60%	50% - 70%
Air Velocity	> 0.152 m/s	0.15 m/s – 0.5 m/s

4.0 RESEARCH METHODOLOGY

This research adopted quantitative approach. The scientific measurement will be conducted in 40 classrooms in UTM by using suitable instruments. The captured reading will be transferred to an observation form and analyzed through descriptive analysis to identify the indoor thermal comfort compliance with the MS1525:2014.

4.1 Sample Profile

Field observation was conducted to assess the indoor thermal comfort in the classrooms in Universiti Teknologi Malaysia (UTM). There are four faculties were selected for this study; including Faculty of Built Environment and Surveying (FABU), Faculty of Engineering (FE), Faculty of Social Science and Humanities (FSSH) and Faculty of Science. A total of 10 classrooms will be chosen from the respective faculty as samples. Overall, there are a total of 40 classrooms involved in this study.

4.2 Measures and Instruments

All physical parameters were measured using the direct-reading instruments. There are two instruments that will be used which known as Hygrometer thermometer and Anemometer. The Hygrometer thermometer (Figure 1) is adopted to measure the Air temperature and Relative humidity, while the Anemometer (Figure 2) is adopted to measure the Air velocity. The model of the Thermometer hygrometer is New Plus-

RE891NP-E3284B and the model of the Anemometer is MS6252A. These instruments are selected because it is designed to measure the indoor thermal environment and have a great accuracy which is $\pm 0.5^{\circ}\text{C}$ - $\pm 0.8^{\circ}\text{C}$, $\pm 2\%$ (RH) - $\pm 2.5\%$ (RH) and $\pm 2\%$ (m/s) for Air temperature, Relative humidity, and Air velocity respectively. Besides, these equipment's are convenient as it gives a fast response at 0.5 seconds for the Hygrometer thermometer and 0.4 seconds for the Anemometer as well as it is easy to use and easy to bring to the sample area.

An observation form was designed to ensure a more systematic and structured measurement process to avoid error in data recoding. The observation form consists of two sections, namely section A and section B. Section A includes the details of the faculty, date, time, and sample classrooms such as building code, floor code, room code, and room name. On the other hand, section B is designed to record the data for thermal comfort parameters within the research context.



Figure 1: Hygrometer thermometer



Figure 2: Anemometer

4.3 Data Collection

The data collection process took four weeks, in February 2019. Measurement of the parameters

in the sample area was conducted in two sessions in a day. The first session was conducted in the morning at 8:30 a.m. to 11:30 a.m., whereas the second session was conducted in the evening at 2:00 p.m. to 5:00 p.m. In addition, the measurements were taken at the optimal time when students are in the classroom and by reference and adoption of Indoor Air Quality Industry (2010) and ASHRAE.

4.4 Data Analysis

Descriptive statistics was adopted to analyze the empirical data collected from field observation. Mean score is used to report the average and range of thermal comfort level for all samples. On the other hand, frequency analysis is used to report on the percentage of the thermal comfort level to identify which classrooms are compliance, below and exceed the MS 1525: 2014. The analyzed data will be compared with the recommended level of thermal comfort as provided in MS 1525: 2014 to disclose whether it complies with the standard or otherwise.

5.0 RESULTS AND FINDINGS

Based on the empirical data gathered, the indoor thermal comfort of the classrooms in UTM were assessed. The assessment was conducted on three parameters, including air temperature, relative humidity and air velocity. Table 2 shows the range of these parameters in the four faculties.

The result as in Table 2 above demonstrated the range of air temperature by four faculties in UTM. The range of air temperature in FABU on morning and evening session was between 21.3°C - 27.5°C , FE were between 23.2°C - 27.5°C , FSSH were between 23.5°C - 27.5°C and FS were between 23.8°C - 27.2°C . Next, the range of relative humidity in FABU in both morning and evening session was between 47% - 64%, FE was between 48% - 62%, FSSH was between 52% - 70% and FS was between 49% - 62%. For the range of air velocity in morning and evening session in FABU, FE, FSSH and FS was between 1.92 m/s - 3.05 m/s, 1.52 m/s - 3.16 m/s, 1.05 m/s - 2.54 m/s and 0.75 m/s - 2.72 m/s respectively.

Table 2. Range of air temperature, relative humidity and air velocity by four faculties in UTM

Faculty	Range of Air Temperature (°C)	Range of Relative Humidity (%)	Range of Air Velocity (m/s)
Faculty of Built Environment and Surveying (FABU)	21 - 26	47 - 64	1.92 - 3.05
Faculty of Engineering (FE)	23 - 28	48 - 62	1.51 - 3.16
Faculty of Social Science and Humanities (FSSH)	24 - 27	52 - 70	1.05 - 2.54
Faculty of Science (FS)	24 - 27	49 - 62	0.75 - 2.72

5.1 OVERALL COMPLIANCE OF INDOOR THERMAL COMFORT LEVEL IN UTM'S CLASSROOMS

This section shows the percentage level of thermal comfort in four faculties, namely air temperature, relative humidity, and air velocity as a whole.

(a) Air Temperature

Figure 3 shows the overall compliance of air temperature level in the UTM classroom according to MS 1525:2014 standard. The study found that majority of the classrooms in UTM which is 70% (28 over 40 classrooms) were complied with the requirement of internal air temperature according to MS 1525:2014 standard. In contrast, another 30% were found not complied with the standard. There are only 8 out of the 40 classrooms (20%) have higher air temperature than the requirement as outlined in the standard. This indicated that indoor air temperature in UTM's classrooms is in good condition.

(b) Relative Humidity

The overall compliance of relative humidity level according to MS 1525:2014 standard in the classrooms is demonstrated in Figure 4. As illustrated in the figure, there are 85% of the classrooms in UTM (34 out of 40 classrooms) were comply to the standard set for internal relative humidity in MS 1525:2014, which the indoor relative humidity was recorded within the range of 50% - 70%. None of the classrooms has humidity level that exceeded 70% as set in the

MS1525:2014. As a whole, it can be concluded that indoor relative humidity of the classrooms is in good condition.

(c) Air Velocity

Based on the empirical data gathered, it was found that the air velocity in the classrooms has not complied with the requirements of MS1525:2014. The results showed that all of the classrooms (40 classrooms) have a higher limit of indoor air velocity, which exceeded 0.5 m/s, see Figure 5.

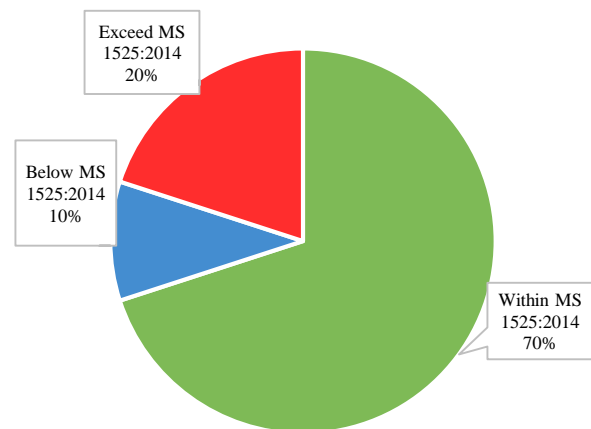


Figure 3. Overall compliance of air temperature level according to MS 1525:2014 in UTM Classrooms

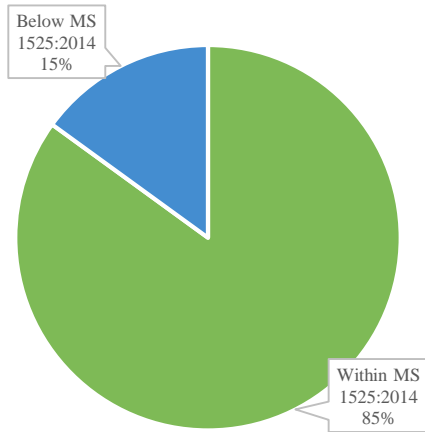


Figure 4. Overall compliance of humidity level according to MS 1525:2014 in UTM Classrooms

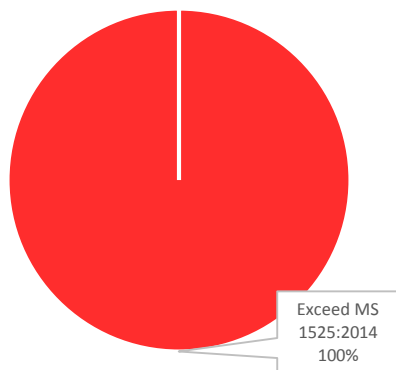


Figure 5. Overall compliance of air velocity level according to MS 1525:2014 in UTM Classrooms

6.0 DISCUSSION

Overall, the air temperature findings showed that the minority of the classrooms of UTM were found not complied with the standard at 30%. There are 20% of the classroom's air temperature were exceed the standard, and only 10% were below the standard. From author observation, the failure to comply with MS 1525:2014 because of the air conditioning was broken and unable to function well. These causes too cold or too hot and affect the indoor air temperature. The air temperature is hotter in the evening session as it is affected by the outside temperature. These results equal with the result of this research as the collected data in the evening session were higher

than the morning session (Jamaludin, Mohammed, Khamidi and Wahab, 2015). A high air temperature affects occupants' health. The disease like a headache and an allergic reaction was reported faced by the occupants due to high indoor air temperature (Meegahapola and Prabodanie 2018). A research review on a total of 93 research articles by Singh *et al.* (2019) has highlighted that the students at each educational stage were highly unsatisfied with the indoor thermal environment and the indoor environment of lower temperature is preferable. In order to improve the indoor air temperature, the facilities manager should ensure that the air conditioning is always in good condition by doing maintenance. Next, the findings of relative humidity show inconsistent result with one of the previous study (Wan Yusoff and Sulaiman, 2014) might due to insufficient sample used in the study. The study uses a minimal number of classrooms (5 classrooms), compared to this study that uses 40 classrooms. Hence the result cannot be comprehensive. The findings of present study showed that 15% of the classrooms were recorded with relative low humidity of below 40% as suggested in the standard. This might be because of small number occupants and the passive activity in the classroom. According to the previous study, the recorded data was high because of the high number of occupants in the medical building and active movement were recorded which produce more body heat exchange (Ahamad and Ping, 2015). Low humidity can affect occupants' health. Low humidity may affect the health of the occupants. Low humidity often leads to dry skin, eyes and mucous membranes (Sunwoo *et al.*, 2006).

The findings of air velocity, on the other hand, showed that none of the UTM classrooms meets the standard set in MS 1525:2014. The indoor air velocity linked with the ventilation system and all the sample area in this study is using mechanical ventilation system through air conditional equipment. During the observation, it was found that all the air conditional in all faculties were failed to function properly which produce fast and loud air velocity. In fact, while performed the field measurement, the author could hear the sound of the air velocity produced by the air conditional. An excellent functional air conditional supposed to produce less sound. It is

suggested to conduct maintenance to the air conditioning according to the requirement.

7.0 CONCLUSION

This study was conducted to investigate the indoor thermal comfort in UTM classrooms. Overall, the findings of indoor air temperature showed that the majority of UTM's classrooms were found successfully comply to the MS 1525:2014 standard at 70 %. In term of relative humidity, the findings showed that 85 % of the classrooms have complied to the requirement of the standard. This study provides insights about the existing indoor thermal comfort in the classrooms in Universiti Teknologi Malaysia in its efforts to enhance the teaching and learning process. The findings of the present study could contribute to the existing limited pieces of literature on the indoor thermal condition of the classroom in Malaysian university. Similar to other studies, there are two limitations worth to be acknowledged. Firstly, the classroom's indoor thermal comfort was assessed merely based on three parameters of the environment factors which are indoor temperature, relative humidity and air velocity. Secondly, the scope of this study was limited to the classroom. The results of this study only reflect the compliance of the indoor thermal comfort in classrooms and should not be generalized to other spaces in UTM such as tutorial rooms, laboratory and other spaces. Hence for further research, it is proposed to adopt a similar methodology in this study to other spaces in UTM or different context.

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