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Thermal Comfort in the Productivity of Students' Learning at Faculty of Technical and Vocational Education

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Abstract: Malaysia is a tropical country with hot and humid weather throughout the year. This will cause an inconvenience to the occupants in a building. Comfort is crucial because it can affect the daily life of the occupants and cause the health of the occupants to be disturbed. This study was conducted to examine the level of student's comfort and focus on learning on the use of laboratories and tutorial rooms in FPTV buildings. The study was conducted in the form of surveys and fieldwork. Therefore, this study uses a qualitative approach through a questionnaire and uses a hygrometer tool for data collection. This study involved 119 students using labs and tutorial rooms. The reliability coefficient of Cronbach Alpha for this study is 0.88. Likert scale for comfort level and thermal sensation lot is used to measure the response of respondents. Data that has been analysed by using IBM Statistical Package for Social Science (SPSS) to frequency, mean, percentage and standard deviation. The test for the hypothesis of the study was carried out through Pearson's correlation to find the connection between thermal comforts with students' focus in the labs and tutorial rooms in the FPTV building. The study results found that thermal comfort (temperature) was not significant with the focus of the students on learning. Meanwhile, for thermal comfort (relative humidity) and thermal comfort (wind movement there is a significant relationship between the concentration of the students but at the (weak) level.

Keywords: Thermal Comfort, Influence Factor, Health Effects, ASHRAE Standard

1. Introduction

Malaysia has an equatorial climate that receives sunshine throughout the year. Generally experiencing a hot and humid tropical climate where the temperature is always hot throughout the year.

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This high humidity rate can cause thermal discomfort to the occupants, especially in a naturally ventilated environment (Mohd Daud et al, 2015).

The comfortable atmosphere of the classroom or laboratory is very important to the students to ensure that learning and teaching objectives are well-functioning (Che Nidzam et al., 2016). Thermal comfort is defined as a state of mind that expresses satisfaction with the thermal environment in terms of (air temperature, relative humidity and wind movement.) According to Idris (2010), a good learning environment can further enhance student motivation and self-esteem. According to Hanafi (1999), the level of comfort of each human being varies according to the local climate. Hence, good laboratory design and lecture designs should be in line with the student's use in any given time and provide comfort to students while in the laboratory or classroom (Abdul Rahman, 2000).

1.1 Problem Statement

The Faculty of Technical and Vocational Education is where students use every space for teaching and learning sessions. Among the factors that cause inconvenience is non-conducive learning rooms. Conductive appropriateness (Rashid, Boon & Syed Ahmad, 2009) will affect the student's day-to-day activities while in the tutorial or laboratory room. Researchers also conducted an early survey to support the issue in this study. The survey was conducted on 67 students around FPTV to get the students' level of comfort first. As a result of earlier studies, 62.7% of respondents were uncomfortable with thermal comfort. This may be due to too high air temperature, and the airspeed in the tutorial and laboratory room is too slow. In addition, 64.2% of respondents were dissatisfied with the thermal comfort level in the labs and tutorial rooms. This is due to the thermal discomfort of students using laboratories and tutorial rooms in FPTV buildings and students focus on learning.

1.2 Research Objectives

The objectives of this study are as follows:

i. To study the thermal comfort level in FPTV buildings according to ASHRAE standards.

ii. To study the level of students' comfort in the FPTV building.

iii. To find out the relationship between student's comfortable comfort and the focus of the students on learning.

1.3 Previous study

A study was conducted on the comfort of students in the classroom (Daud, 2015). This study aims to measure the change of weather parameters, evaluate the students' perceptions of the students, and involve measuring students' comfort. The method used in this study was by using questionnaires and interview methods informally with the respondent. The second method used in this study is a thermal comfort multi-station measurement tool. It is used to record parameter data such as ambient temperature, average radial temperature, air pressure, noise, wind velocity, relative humidity, carbon dioxide gas concentration and illumination. The findings of this study are that the total number of male students in the comfort range is also much higher than 32 people compared to 16 female students. This condition shows that their acclimatisation level is very high in hot and dry temperatures, especially in women who wear *baju kurung* with a scarf. This shows that the main factors that cause thermal discomfort to the students are due to the wear factor used. This is because girls wear more clothes than men.

2. Methodology

In this research project, field measurements and questionnaire surveys were conducted to obtain the data. This study was conducted quantitatively using descriptive analysis. A set of questionnaires is used to collect data. The set of questionnaires was the main instrument in the survey because this was the most effective and widely used method by other researchers in conducting a previous study. However, the total number of samples selected by the respondents was 119 persons, and the sampling was according to the sample selection method by Krejcie and Morgan (1970). Respondents were selected using a randomised approach, where researchers identified individuals with information that was relevant to the phenomenon they wanted to study (Merriam, 2009). Sample selection is randomly easy. The researcher distributed a questionnaire to the students involved using the tutorial room and laboratory at FPTV. The physical measurement and subjective measurement were compared with the ASHRAE Standards. The main objectives of this study were to identify the relationship between student's comfortable comfort and the focus of the students on learning.

2.1 Temperature Measurement

The researchers made measurements through fieldwork in laboratories and tutorial rooms. The researchers selected three laboratories and three tutorial rooms. To answer the question of the first study, measuring the level of thermal comfort in the FPTV building is by measuring temperature and relative humidity. These measurements are performed on different days and at the same time several times with Ms6508 Digital Temperature Humidity Meter hygrometer for temperature and relative humidity measurement. The measurements are made in each room and selected laboratories. In addition, relative temperature readings and humidity are taken inside the selected labs and tutorial rooms. The data obtained are recorded and analysed.

2.2 Questionnaire Form

The questionnaire was developed to determine the level of inner comfort and student satisfaction at the Electric Wiring Laboratory and Tutorial Room at FPTV, UTHM. Questionnaire was the easiest and fastest way to obtain information for the survey study (Majid, 2000). According to Gay et al. (2009), a questionnaire is commonly used in survey studies. It can improve the accuracy and feedback given by the respondents as the researcher's actions do not influence it. Respondents are also free to express their own opinions to answer the questions.

Table 1: Measuring scale for subjective thermal sensations (Fanger, 1970)

Likert's Scale					Interpretation
	Scale	Air Temperature	Relative Humidity	Air Movement	Based on Fanger's Theory:
7 Thermal Sensation Sortation Vote	-3	Very Cold	Very Dry	No movement at all	(-3, -2) Unacceptable condition
	-2	Cold	Dry	Average movement	
	-1	Quite Cold	Quite Dry	Quite no movement	(-1,0,1) Acceptable condition
	0	Neutral	Neutral	Neutral	
	1	Quite Hot	Quite Humid	Quite windy	
	2	Hot	Humid	Average windy	(2,3) Unacceptable condition
	3	Very Hot	Very Humid	Very windy	

The questionnaires were divided into three parts, namely A, B, and C. Part A is the data for demographics that contains respondents' backgrounds and basic information. Demographic data consists of gender, age, race, the field of study and years of study. This is to obtain information that can be used to carry out this study. In section B, the items collected through the questionnaire were to collect data relating to the student's level of comfort in the Lab and Tutorial room at the Faculty of Technical and Vocational Education, UTHM. In the questionnaire, there are two parts, namely B1 and B2. For the

B1 part, the scale used is based on Table 1, the subjective measurement scale for thermal sensation. Data collection for thermal sensation scores was categorised into three parts which is (-3, -2), (+2, +3) and (-1, 0, +1). According to Fanger (1970), the acceptable range for the thermal sensation is the scale (-1, 0, +1).

After respondents vote for their thermal sensations based on air temperature, relative humidity and air movement in section B1, they will rate their perception on their acceptance of thermal comfort based on temperature, relative humidity and air movement in section B2 that measured based on an ordinal scale as shown in Table 2.

Table 2: Comfort Measurement Scale (Mishra & Ramgopal 2014)

Opinion	Score
Strongly disagree	1
Disagree	2
Agree	3
Strongly agree	4

Questions for section C were developed to measure student perceptions on the effects of internal thermal comfort and student satisfaction on learning in labs and tutorial rooms. Respondents will provide feedback based on Table 3.

Table 3: Five Points Likert Comfort Measurement Scale

Guideline	Score
Strongly disagree	1
Disagree	2
Not sure	3
Agree	4
Strongly agree	5

3. Results and Discussion

The results obtained through fieldwork that using the Hygrometer Digital Temperature Humidity Meter were analysed using Microsoft Office Excel 2007. Graphics charts and bars are used to simplify the presentation of data collected. Besides that, data from respondents through a set of questionnaires distributed in laboratories and tutorial rooms by researchers were analysed using SPSS (Statistical Package for Social Science).

3.1 Data Analysis by Observation

Based on the results shown in Figure 1, the highest average temperature recorded in the morning is in tutorial room 2, which is 29.2 °C. The lowest temperature morning was at Electric Wiring Laboratory at 28.4 °C. For average temperature readings at midday, it was higher than in the morning, welding and metal fabrication laboratories recorded the highest temperature at 31.6 °C. In contrast, the lowest temperature recorded at noon was in the General Machining Laboratory 30.7 °C. The highest average temperature reading is the Electric Wiring Laboratory of 30.5. While the lowest average reading temperature is recorded in tutorial room 3.

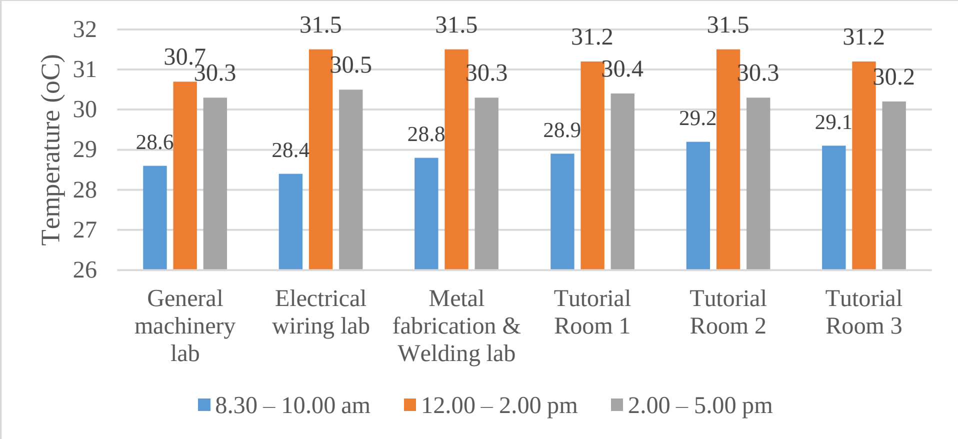

Figure 1: Average Temperature for Tutorial Room and Lab

Based on Figure 2, the average relative humidity readings in the morning were the lowest in the general machining laboratory of 58.8%. In comparison, the highest average reading value is in the electrical wiring laboratory which is 68.2. In the peak time of the day, the average value reading graphs are up and down. The highest relative humidity readings were recorded in tutorial room 1, which is 66%. In contrast, the lowest average relative humidity was recorded at 56.8%, in general machining laboratories. The lowest relative humidity reading value recorded in the afternoon was 63.1%, in general machining laboratories. The highest reading value is in tutorial room 3, which is 66.8%.

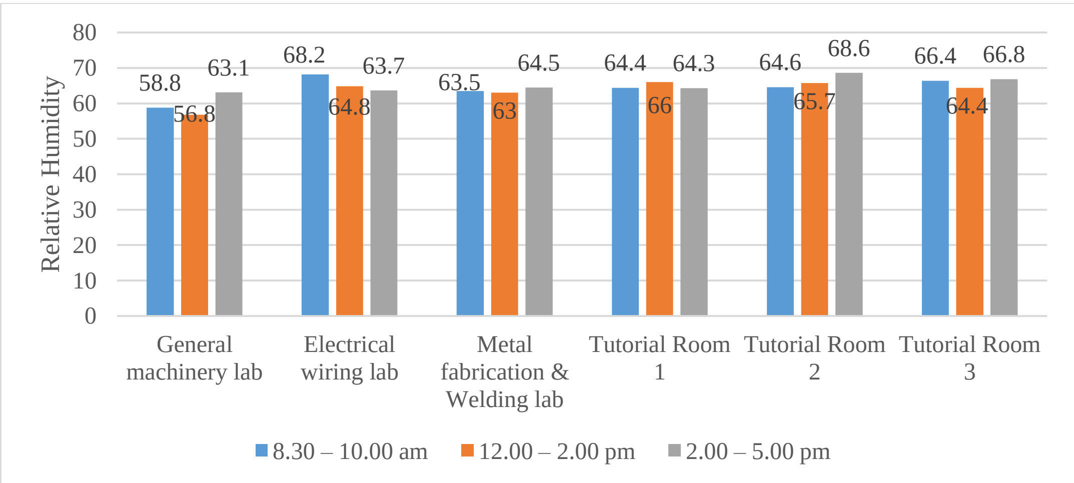

Figure 2: Average Relative Humidity in Tutorial Room and Laboratory

3.2 Data Analysis by Questionnaire

The respondents' distribution for the frequency and percentage of thermal sensation score on Temperature, Relative Humidity and Air Movement are shown in Table 4. The temperature analysis results showed that the majority of respondents were 87 students (73.1%) experiencing 'Somewhat hot' at this research site. The second highest respondent was 18 respondents (15.1%) experiencing 'Neutral' sensation. While 12 people experience a 'Hot' sensation. Respondents with 'Cold and Cold' sensations are only one person, at 0.8 percent.

Table 4: Frequency and Percentage Value for Thermal Sensation (Air Temperature, Relative Humidity and Wind Movement)

Thermal Sensation Sortation	Air Temperature (Item 1)	F	%	Relative Humidity (Item 2)	F	%	Air Movement (Item 3)	F	%
-3	Very cold	0	0	Very dry	0	0	No movement	1	0.8
-2	Cold	1	0.8	Dry	0	0	Average	6	5.0
-1	Quite cold	1	0.8	Quite dry	10	8.4	Quite no movement	62	52.1
0	Neutral	18	15.1	Neutral	46	38.7	Neutral	41	34.5
+1	Quite hot	87	73.1	Quite humid	35	29.4	Very windy	6	5.0
+2	Hot	12	10.1	Humid	28	23.5	Average windy	3	2.5
+3	Very hot	0	0	Very humid	0	0	Very windy	0	0
	Total	119	100	Total	119	100	Total	119	100

Note: (-3,-2) (+2, +3) = Unacceptable, (-1, 0, +1) = Acceptable

For relative humidity, the majority of respondents were those who experienced a 'Neutral' (38.7%) sensation followed by 'Slightly sluggish' sensation (29.4%) and 'moist' sensation (23.5%). The results obtained from the questionnaires mainly were in the category (-1, 0, +1), which showed that the laboratory and tutorial room environment was acceptable. For the parameters of air movement, most respondents obtained a 'Not moving' (52.1%) sensation and followed by sensation 'Neutral' (34.5%). While for the 'Breezy' and 'Simple not moving' sensation is as much (5%). In conclusion, based on Fanger's theory (1970), a total of 13 respondents were in an unacceptable environment (temperature). Meanwhile, for relative humidity, only 28 respondents were at an unacceptable level. For wind movement, 110 respondents are at an acceptable level of environment.

The second question is to examine the level of thermal comfort acceptance among the students in the tutorial and laboratory room based on the mean score and the standard deviation obtained through the questionnaires answered by the respondents. There are three categories for students' comfort measurement levels: comfort in terms of temperature, relative humidity & air movement. Table 5 shows the mean score analysis and the standard deviation of thermal comfort items for temperature, humidity, and air movement in laboratories and tutorial rooms in FPTV buildings.

Table 4: Level of students' perception on Thermal Comfort in Tutorial and Laboratory Room.

Item No	Item	Mean	Standard Deviation	Level of agreement	Overall Mean Average
4.	Temperature	2.31	0.46	Average	
5.	Relative Humidity	2.94	0.30	Average	Average (2.7)
6.	Air Movement	2.85	0.37	Average	

Note: High Level= Mean between (3.01-4.00), Average Level= (2.01-3.00) and Low Leve = (1.00- 2.00)

Based on Table 5, the highest mean score for the thermal comfort level is the air moisture sensation with a mean (M = 2.94, SD=0.3). In comparison, the lowest mean score was at temperature sensation with a mean (M= 2.31, SD=0.46). Thus, the analysis results showed that the overall mean score was moderate for the student's comfort level in using labs and tutorial rooms.

3.3 The Relationship Between Student's perception of Thermal Comfort with Students' learning focus

The third question is to identify the level of thermal comfort that affects the students' focus using the tutorial room and lab in the FPTV building. There are three categories of students' level of comfort, namely high level, moderate level and low level. Table 6 shows the mean distribution and the standard deviation obtained for thermal comfort items affecting student focus on learning.

Table 6: Analysis of the correlation test of the Relationship Between Thermal Comfort Level (Temperature, Relative Humidity, Air Movement) with Focused Students using the Tutorial Room and Laboratory.

Correlation				
		Thermal comfort level (Temperature)	Thermal comfort level (Relative Humidity)	Thermal comfort level (Air Movement)
Student Focus Level	Correlation Pearson (r)	0.149	0.192	0.272
	Significant	0.106	0.036	0.003
	N	119	119	119

This part examines the relationship between thermal comfort in terms of temperature, relative humidity, and air movement that might influence students' focus. For this purpose, the researcher adopted the Karl Pearson coefficient of correlation as the statistical tool. Table 6 shows the result from the Pearson correlation test. The relationship between the student's focus and the level of thermal comfort is presented through the value reading of the correlation coefficient (r). In contrast, the significant relationship between the two variables can be seen through the significant values. From table 6, it is found the value of the coefficient for thermal comfort variable (temperature) with the concentration of the student is very weak (r = 0.149) at a significant value of 0.106. This shows no significant relationship between the students' focus and thermal comfort (temperature).

While the correlation coefficient for the thermal comfort variable (relative humidity) with the student's focus is very weak (r = 0.192) at the significant value of 0.036. This shows a significant relationship between students' focus and thermal comfort (relative humidity) but at a very weak level. For thermal comfort variables (wind movement) with the student's focus is at weak level (r = 0.272) with significant value r = 0.003. This shows a significant relationship between thermal comfort (wind movement) with the focus of the students but at a weak level.

Overall, only two items have a significant relationship: thermal comfort level for air movement and relative humidity. Significant relationships will be obtained if the results show a sig = 0.000 <0.05. In terms of thermal comfort for temperature, there is no significant relationship.

3.4 Discussions

The air temperature for the laboratory and tutorial room in the FPTV building is not according to the prescribed ASHRAE-55 standard. ASHRAE-55 (2004) states that the air temperature for each individual in each room is 25.4 °C for men and 25.8 °C for women. This indicates the thermal comfort level of the room and the laboratory does not comply with ASHRAE-55 standards. While Fanger and Langklide (1970) the most suitable temperature for each individual is 25.0 °C - 25.1 °C only. The laboratory and this tutorial room cannot match the temperature set by the ASHRAE standards due to direct sunlight to the building. In addition, the ventilation in the laboratory and the tutorial room does not have a good ventilation system. Therefore, the temperature in the lab and the tutorial room will increase especially when the space is filled by the student and exceeds the prescribed capacity.

The relative humidity of the laboratory and tutorial room in the FPTV building is according to ASHRAE (2004) standards, where it is at a high level too dry and not too moist. The ASHRAE 55-2004 standard has outlined the relative humidity of suitable air in the lab, and the tutorial room is between 50% - 60%.

3.4.1 The Level of Students' Comfort in The FPTV Building

The thermal comfort level in the tutorial room and laboratory at the FPTV floor is at a moderate level. The thermal comfort level is in acceptable condition even though the air temperature in the room is quite hot. Yu (1997) argues that the occupant's condition of space will affect thermal comfort. This is due to the level of activity, type of use, age, body weight and gender of the occupants. This study shows that the majority of the student's wear fairly thick garments, short pants, work clothes, long pants, and scarves. In addition, air temperature is the most important parameter to determine the level of thermal comfort over each individual occupying a space to see the impact on ventilation (ASHRAE-55, (2010). Air temperature can also determine whether a tutorial room or laboratory in FPTV buildings is hot, cold, comfortable, and uncomfortable.

3.4.2 The Relationship Between Student's Comfortable Comfort and The Focus of the Students On Learning

For the level of thermal comfort (temperature) with the student's focus is very weak r = 0.149 at a significant value of 0.106. This shows that there is no significant relationship between the concentration of students with thermal comfort (temperature). This can be proved when most students using the space experience discomfort to thermal comfort (acceptable levels) but can still focus on their learning. This may be due to the student's emotion because it has the desire to learn even in discomfort. Thermal comfort is a very important factor in the investigation of a room in the FPTV building. This is because thermal comfort is a reaction to temperature changes in their environment. This is supported by the previous study by Pintrich (2004), comfort or discomfort for the students does not have any effect on the learning. The students can continue to conduct practical activities and learning normally without complaining about the surroundings. Researchers are also sensational to these students, but they are still not impressed with the thermal comfort conditions in labs and tutorial rooms in FPTV buildings.

4. Conclusion

In conclusion, from the study's findings, the data analysis through SPSS and fieldwork showed that all the study objectives were achieved. This research aims to see the level of thermal comfort for laboratories and tutorial rooms. Additionally, to look at students' level of comfort using the tutorial and laboratory rooms and the effect of thermal comfort on students' focus on learning. Furthermore, the findings from the analysis through the questionnaire showed that the students had symptoms of symptom pain, fatigue, skin dryness, dizziness and flu symptoms. According to ASHRAE 55 -2010, based on the study findings, the effect on thermal comfort on an individual will affect the impact of one's activities. For example, if a student experiences thermal discomfort in the classroom, it will affect the student's attention in the classroom. The researcher obtained the different findings of the study. Even though students in the classroom suffer from thermal discomfort, they can focus on teaching and learning sessions.

Lastly, thermal comfort is a very important factor for an individual in a learning environment. However, for this research, the focus factor of the students in the tutorial and laboratory room is not disrupted even though the space does not have a good level of thermal comfort. However, other factors that influence the research findings that are not studied in this research can be considered for future study.

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