EFFECT OF TEMPERATURE ON TASK PERFORMANCE AND THERMAL COMFORT AMONG UNDERGRADUATES OF UMP

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Report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Occupational Safety and Health

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DECEMBER 2016

SUPERVISOR'S DECLARATION

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Dedicated to my beloved supervisor, family and friends.

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ABSTRACT

Indoor air temperature may negatively affect human performance rate and human physical response if it is not properly controlled. Effects of indoor air temperature on task performance and its contribution to the occurrence of thermal comfort had become a focus of studies. However, until now inconsistent results were yielded from those studies. In this paper, the relationship between the thermal comfort and task performance was discussed, as well as the thermal comfort among respondents. Typing test was used as an indicator of evaluating task performance. ASHRAE Thermal Sensation Scale was also used to evaluate the range of acceptance temperature. Based on the result, 23°C is the most comfortable temperature and most accepted. In conclusion, the study showed that thermal comfort ($p<0.05$) and task performance ($p<0.05$) were significantly difference under different temperature settings, but thermal comfort did not show any relationship with task performance ($p>0.01$).

ABSTRAK

Suhu boleh mempengaruhi pretasi kerja dan tindak balas fizikal manusia jika ia tidak dikawal. Kesan suhu atas pretasi kerja dan berlakunya keselesaan terma adalah fokus kajian. Tetapi, sampai sekarang tiada hasil kajian yang konsisten. Dalam kajian ini, hubungan antara keselesaan terma and pretasi kerja telah dikaji, dan juga keselesaan terma antara responden. Kerja menaip digunakan sebagai parameter untuk menguji pretasi kerja. Skala *ASHRAE Thermal Sensation* juga digunakan untuk menilai julat suhu penerimaan. Hasik kajian nenunjukkan 23°C ialah suhu yang paling selesa and paling diterima. Kesimpulannya, kajian menunjukkan perbezaan ketara antara keselesaan terma ($p<0.05$) dan prestasi kerja ($p<0.05$) di bawah tetapan suhu yang berbeza, tetapi keselesaan terma tidak menunjukkan hubungan dengan pretasi kerja ($p>0.01$).

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter mainly emphasizes on the general idea of this study along with the problem statements, objectives, significance of study and the scope of study.

1.2 BACKGROUND OF STUDY

Temperature can be defined as average kinetic energy in a body (Parsons, 2003). Generally, indoor temperature is one of the fundamental characteristics of the indoor environment. The indoor temperature can affect the human response, such as thermal comfort, performance at work, perceived air quality and sick building syndrome symptoms (Seppänen, Fisk, & Lei, 2006).

According to ASHRAE (2009), thermal comfort was defined as psychological state of expressing satisfaction towards surrounding thermal environment. Every human has their own thermal sensation based on their physiological and psychological state. There are two different approaches to determine the thermal comfort, but the most common approach is Fanger's Predicted Mean Vote (PMV). Seven points ASHRAE thermal sensation scale is used in the PMV model. The thermal comfort condition is where at least 80% of the occupants are satisfied.

There are many studies over the years on the relationship between the temperature and the task performance. In the study of (Seppänen et al., 2006), they showed a positive influence of temperature on the task performance. The task performance can be included as text processing, simple mathematics equation and writing- based task. Same goes to the study of Cui et al. (2013), they proved that temperature influences the task performance greatly. The optimum temperature for efficient task performance is 25.8 °C.

1.3 PROBLEM STATEMENT

Temperature is an ergonomic factors, which if not controlled properly, can negatively affected the human physical condition and performance rate (US Department of Labor, 2000)

Based on the study of Tham & Willem (2010), it shows that by increasing the temperature and relative humidity. it will significantly decreased tear film quality and the concentration of salivary alpha-amylase. All these physiological conditions indicating that lower mental arousal and alertness. Thus, high temperature will lower task performance.

As mentioned on above, extreme temperature can affect physiologically. Lan et al. (2011) had conducted a research on 12 subjects and investigated the effect of thermal environment on health problem. The result shows that the respondent’s heart rate, respiratory ventilation, and end-tidal partial pressure of carbon dioxide increased significantly and their arterial oxygen saturation decreased. The results implied that the temperature brings negative effects on health when people feel thermally warm or discomfort.

Extreme temperature will causes thermal discomfort and people are more easily to get distracted and lost motivation. Cui et al. (2013) had conducted an experiment to study the effect of temperature on thermal comfort, motivation and task performance. It has been proven in this study that the learning effect was greatly affected by temperature. Changes on task performance rate is not only influenced by the environment factor, temperature, but also the subjective factor, motivation. Motivation is improved when the surrounding temperature is comfortable to them. Eventually, as motivation level increases, the task performance rate increases as well.

1.4 CONCEPTUAL FRAMEWORK

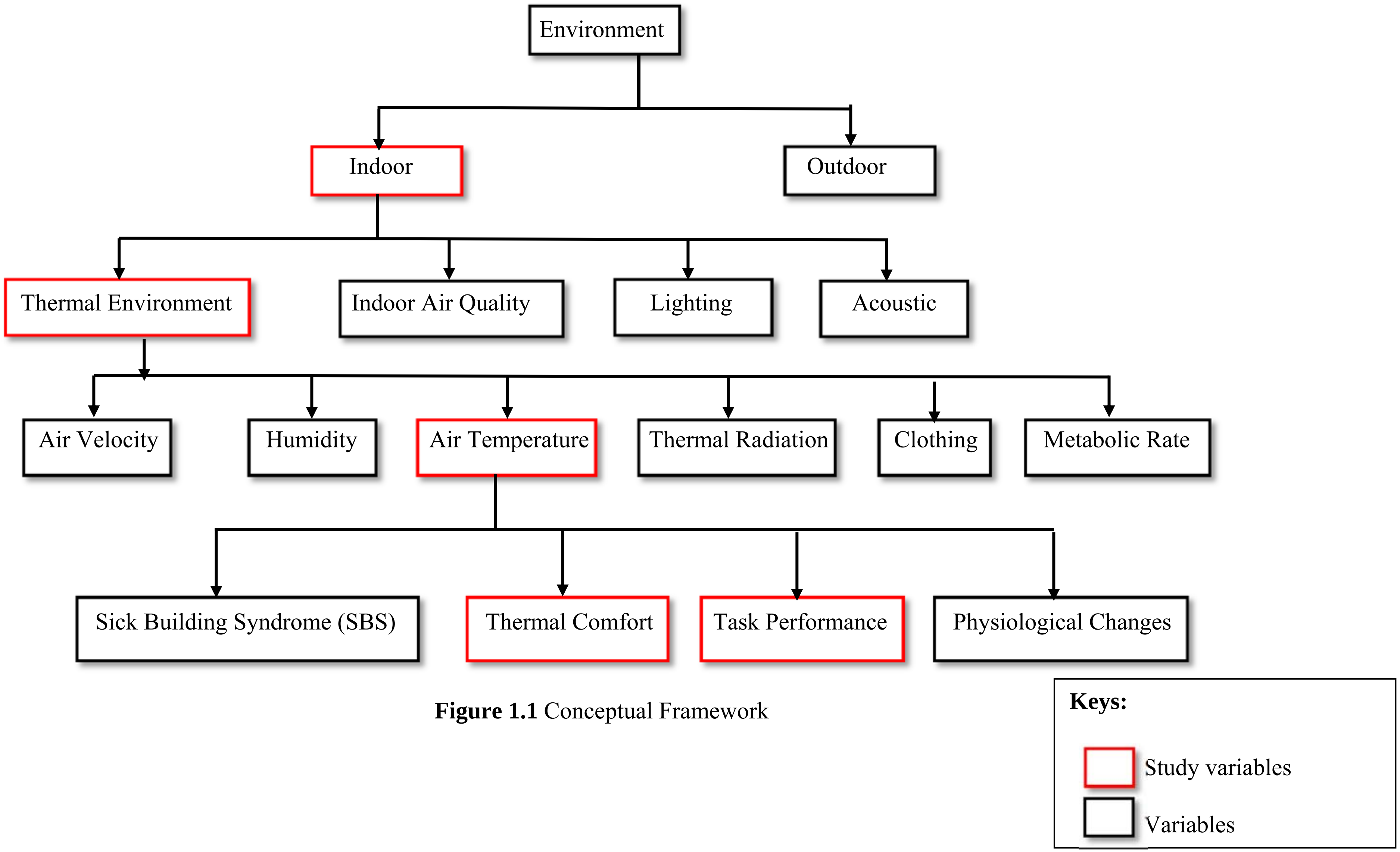

Figure 1.1 Conceptual Framework

1.5 RESEARCH OBJECTIVES

1) To compare the thermal comfort of undergraduate students of FTEK, UMP at three different temperature settings.
2) To compare the task performance of undergraduate students of FTEK, UMP at three different temperature settings.
3) To determine the relationship between thermal comfort and task performance at three different temperature settings.
4) To determine the relationship between age, genders, BMI and ethnicity with task performance under three different temperature settings.

1.6 RESEARCH QUESTIONS

1) What is the acceptable temperature which majority of undergraduates of UMP feel comfortable and highest acceptability?
2) How is the task performance rate of undergraduates of UMP under three different temperature settings?
3) What is the relationship between thermal comfort and task performance among undergraduates of UMP?
4) What is the relationship between age, genders, BMI and ethnicity on task performance among undergraduates of UMP?

1.7 RESEARCH HYPOTHESIS

1) There is significant difference of thermal comfort of undergraduate students of FTEK, UMP under three different temperature settings.
2) There is significant difference of task performance of undergraduate students of FTEK, UMP under three different temperature settings.
3) There is significant relationship between thermal comfort and task performance under three different temperature settings.
4) There is no significant relationship of age, genders and ethnicity of undergraduate students of FTEK, UMP on task performance under three different temperature settings.

1.8 SIGNIFICANCE OF STUDY

The relationship between air temperature and human task performance had become a study subject of hundreds of studies, yet, inconsistent results were yielded from those studies. This study is significant in order to determine the effective temperature for task performance and the temperature that can satisfied most of the occupants. The findings of this study is crucial and useful to ensure the administration of the UMP can take needed action to manage the temperature of the lecture halls and the offices in UMP in order to achieve the effective task performance and thermal comfort.

1.9 SCOPE OF STUDY

The effect of the temperature on task performance and thermal comfort had conducted among undergraduates of Faculty of Technology Enginnering students in UMP. This study will focus mainly on the effect of temperature and performance rate. Besides that, this study also emphasized on the thermal comfort and room temperature that satisfy the respondents.

1.10 DEFINITION OF TERMS

1.10.1 Conceptual Definition

Temperature

Temperature, in the context of physic, is defined as average kinetic energy in a body (Parsons, 2003).

Thermal Comfort

According to ASHRAE (2009), thermal comfort is defined as psychological state of expressing satisfaction towards surrounding thermal environment. Thermal sensation is different among people based on individual physical and psychological state.

Task Performance

Task performance, as known as productivity, can be defined as ratio of a volume measure of output to a volume measure of input use (Oecd, 2001).

1.10.2 Operational Definition

Temperature

Room temperature of this study can be measured by Wet Bulb Globe Temperature (WBGT) and the setting control on the chamber itself. The temperature was set to the 20°C, 23°C and 26°C for this study.

Thermal comfort

Thermal comfort for this study is determined by the ASHRAE Thermal Sensation Scale. There are 7 points of scale which present the current thermal environment. The respondents were required to choose one condition based on their thermal sensation they felt.

-3	-2	-1	0	1	2	3
cold	cool	slightly cool	neutral	slightly warm	warm	hot

Figure 1.2 ASHRAE Thermal Sensation Scale

Task Performance

Task performance can be measured by the speed of word typing. The respondents were required to type as fast as they could based on the article provided (Buchberger, 2008).

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Effects of temperature on task performance had become a study subject of hundreds of studies. Yet, inconsistent results were yielded from those studies. In this chapter, past researches on this study will be discussed in order to gain more knowledge and understandings. This chapter will emphasize the past researches' findings on indoor temperature, thermal comfort and how these two factors affect the task performance.

2.2 TEMPERATURE

At a molecular level, temperature can be considered as the average kinetic energy in a body. The human body will continuously produces heat due to the basal metabolism and muscular metabolism (Vanos et al., 2012). The heat produced must be released into environment in order to reach a stable body temperature. In order to maintain an optimum body temperature, the human body will respond to temperature in a dynamic way.

Human is homeotherm and will try to maintain internal body temperature near to around 37°C. For example, in warmth conditions, the body will respond by vasodilation which the blood vessels expand and increase the blood supply to body and thus the heat is released from the body. On the other hands, the body will respond by vasoconstriction when in cold environments. Vasoconstriction will reduce the blood supply to the body and keep the heat inside the body.

According to Roelofsen (2002) study, he had identified that human performance has a close relationship to the indoor environment quality (IEQ). The IEQ covers several factors which thermal environment, indoor air quality, lighting, and acoustic. Thermal environmental elements are including air temperature, humidity, air velocity, thermal radiation, clothing, and metabolic rate (Takada, Matsumoto, & Matsushita, 2013). All these six elements are the basic variables that affect human response to thermal environments. Air temperature is the common indicator of thermal environment in IEQ and performance research (Cui et al., 2013).

Air temperature can be defined as the temperature of the surrounding the human body which determines the heat flow between the human body and the air. Other than the influence of air temperature, radiant temperature is one of the factors on determining the effect of temperature on human body. However, according to Parsons (2003), he assumed that the radiant temperature is equal as air temperature in term of thermal comfort. Air temperature, air velocity and humidity are measured via Wet Bulb Globe Temperature (WBGT).

2.2.1 Effect of Temperature and Task Performance

The relationship between air temperature and human task performance had become a study subject of hundreds of studies, yet, inconsistent results were yielded from those studies. In one of the studies by Fang et al. (2004), 30 female respondents and exposed to three different environment conditions (20°C /40%, 23°C /50%, 26°C /60%) for 280 minutes, they showed that performance of office work was not significantly affected by indoor air temperature and humidity.

Besides that, in a study of Kahl & Voorhis (2005), they showed that room temperature do affected the physical comfort, but there is no impact on human task performance in mathematics, reading comprehension, or word recall.

However, in a study of Lan, Lian, & Pan (2010), they shown an opposite result from the Kahl and Fang et al.. They had experimented on 21 volunteered participants with three different air temperature (17 °C, 21 °C, and 28 °C). They used computerized neurobehavioral tests during exposure in the lab to measure the participants' performance. The results indicate that thermal discomfort caused by air temperature had negative influence on office workers' productivity. The rating scales supplements in the neurobehavioral performance were useful when evaluating the effects of IEQ on productivity.

Effect of work on hot environment had conducted by O'Neal & Bishop (2010) with 10 respondents. They were tested with three different simple mental task tests in 30°C and 38°C hot environment. The task were short-term memory test (MEM), simple arithmetic test (MATH) and computerized reaction time/tracking test (RTT). The study suggesting that the heat and physical activity did alter cognitive performance.

In a study by Melikov et al. (2013), they required the participant exposed to three different temperatures of 23°C, 26°C and 28°C in climate chamber. The experiment was held for four hours. Sudoku test was used as parameter for task performance. At the end of the experiment, subjective responses were collected through questionnaires. Physiological test was taken. The results showed that by increasing the temperature and relative humidity, it will significantly decreased tear film quality and the concentration of salivary alpha-amylase. All these indicating lower mental arousal and alertness.

According to Cui et al. (2013), 36 subjects were recruited and exposed to 5 different temperatures which are 22 °C, 24 °C, 26 °C, 29 °C, 32 °C for 150 minutes. The parameter used to measure the performance rate were the memory typing and the number of correct letters. It has been proven that performance rate was greatly affected by the temperature. Compared with 26 °C, the performance at 22 °C and 32 °C was around 5% and 8% lower, respectively. From significant test, the performance at 29 °C was significantly lower than 26 °C, and the performance at 32 °C was significantly lower than 24 °C and 26 °C. In short, the optimum temperature for performance in this study was 25.8 °C.

2.2.2 Effect of Temperature on Subjective Response

Subjective responses of an individual towards thermal comfort, thermal sensation, thermal preference and thermal acceptability were determined by the room's temperature.

Seppänen, Fisk, & Lei (2006) had collected and analysed the literature that relating to the performance in work and temperature. From their finding, room temperature could influence the productivity. From all the data, they summarized that performance increases with temperature up to 21-22 °C, and decreases with temperature above 23-24 °C. The highest productivity was at temperature of around 22 °C.

Wafi, Ismail, & Ahmed (2011) had conducted a study on selected hostel in Universiti Sains Malaysia (USM). Two methods were used to measure the subjective response towards thermal comfort and the environment conditions. The study was involving more than 900 students and conducted daily for a week. The data of indoor comfort was collected from questionnaire survey. It was observed that comfort temperature for the Malaysian student is 28.5 ºC.

According to Shaharon & Jalaludin (2012), 99 respondents are random selected and conducted in the office for 5 days. Babuc A instrument was used to collect environment parameter which were dry bulb temperature, relative humidity, radiant temperature and air velocity. Subjective thermal comfort data were recorded using a questionnaire adapted from ASHRAE (2004). The study showed that the thermal comfort zone temperature was identified to be within the range of 21.6-23.6°C and relative humidity of 42-54%.

2.3 THERMAL COMFORT

According to ASHRAE (2009), thermal comfort was defined as psychological state of expressing satisfaction towards surrounding thermal environment. Thermal sensation is different among people based on individual physical and psychological state. The zone of thermal comfort is defined where the environment condition or temperature is accepted by 80% of the people.

There are many studies on ways to evaluating thermal comfort if the thermal environment is optimum or suitable for living and task performance. Most of the researchers used ASHRAE Standard 55, ISO 7730 and Fanger's Model to determine appropriate thermal conditions. The Fanger's Predicted Mean Vote (PMV) equation has been used as an international standards to predict thermal sensation of occupants (Simons, Koranteng, Adinyira, & Ayarkwa, 2014).

2.3.1 Thermal Comfort Approach: Fanger's PMV Model

There are two major approaches to define thermal comfort which are Heat Balance Approach and Adaptive Approach. The heat balance approach uses data based on the experiment in climate chamber while the adaptive approach is based on field studies on thermal comfort. The predicted mean vote (PMV) is the most common model used and best model to support the theory of the heat balance approach.

Fanger (1970) believed that four physical variables (air temperature, air velocity, mean radiant temperature, and relative humidity) and two personal variables (clothing insulation and activity level) are the variables of predicting the thermal comfort. Later on, Fanger (1982) had conducted his study on a large group of people regarding their acceptable thermal comfort. The subjects exposed to different temperature conditions in the climate chambers. In the study, the respondents are required to dress in standardized clothing and completed standardized activities. After the study, the respondents were asked to give their opinions according to the ASHRAE Thermal

Sensation scale which have seven points scale. A mean vote (MV) was obtained after the experiment.

Fanger's PMV model is based on thermoregulation and heat balance theories. As mentioned as above, the human body will maintain the heat balance between the heat produced by metabolism and the heat lost from body by some physiological process. In other words, maintaining the heat balance is a must for achieving the thermal sensation (Charles, 2003). However, Fanger stated that human's thermoregulatory system is quite effective when creating heat balance even if comfort does not exist. Fanger also found that physiological process influencing the heat balance was skin temperature and sweat rate.

In order to prove the validity, Fanger had conducted a study on 20 participants to show the relationship between activity levels and sweat rate. The participants are asked to wear standardized clothing and perform four different level of activities. Later on during 1970, Fanger had combined other researcher's data with himself and expand the thermal equation. This thermal equation slowly are related to the seven points ASHRAE thermal sensation scale which is known as PMV Index.

The Institute for Environmental Research of the State University of Kansas had conducted a research on subject thermal comfort in sedentary regime to obtain a model to express the PMV in terms of parameters in an environment. The subjects were undergone the sedentary metabolic activity, dressed with normal clothes and with a thermal resistance of approximately 0.6 clo for three hours. The finding showed that the optimum comfort level was nearly to 26°C and 50% relative humidity.

PMV model is designed to predict the average of thermal comfort within a space. However, Fanger (1970) found that even if the thermal environment is maintained according to the PMV model, there will be some respondents are uncomfortable with the thermal environment. Fanger acknowledged these differences between people and categorized it as Predicted Percentage Dissatisfied (PPD) index. This PPD model predicts the percentage of people who are likely to be dissatisfied with a given thermal environment. In other words. at the neutral temperature defined in the PMV index, PPD indicates that 5% of the occupants will dissatisfied with the thermal environment (Charles, 2003). As PMV changed in either the positive or negative direction, PPD increases (Shaharon & Jalaludin, 2012).

PMV model has been used globally and widely to predict the acceptable thermal environment, however, there are some limitations and applications on the PMV model and requires revising (Humphreys & Fergus Nicol, 2002). Many thermal comfort studies suggested that the accuracy of PMV is the issue (De Dear, 2004). PMV model does not always accurately predict the actual thermal sensation of occupants, especially in field studies. The PMV model is based on the climate chamber experiments where the 6 variables can be monitored and accurately maintained. According to Schiavon & Melikov (2008), people live in changeable and inconsistent environment, unlike the temperature is consistent throughout the climate chamber experiment, therefore the PMV failed to predict the acceptable thermal environment. Ealiwa, Taki, Howarth, & Seden (2001) suggested that field studies experiment are closer to the reality in this thermal comfort area. Besides that, Doherty and Arens (1988) also agreed that the PMV model is available model to evaluate or identify the thermal comfort for office work activity or steady-state activity only.

2.3.2 Thermal Comfort and Task Performance

According to Kahl (2005), temperature had affected individual on thermal comfort and sensation, but they are no significant decrement or increment on the task performance. Similarity, Zhang, Arens, Kim, Buchberger and et al. (2010) showed that the typing rate as task performance assessment among all the temperatures are insignificant. However, some studies had found that task performance was strongly correlated with the thermal comfort (Rohles, 1974).

Lan, Wargocki, Wyon, Lian (2011) has conducted their study on 12 respondents regarding the effect of discomfort and task performance. Participants are exposed to 2 different conditions which are 20°C and 30°C of temperature in working office.

Physiological measurements such as body temperature and heart rate are taken. Office task are performed as parameters of performance. The results showed that the performance are decreased when the workers are felt warm. Besides that, their heart rate and body temperature are increased significantly.

2.4 TASK PERFORMANCE

Task performance, as known as productivity can be defined universally as the ratio of output to input. There has been many studies interested in the relationship between heat and task performance. Some researches showed that there are no significant effect between heat and task performance (Fang et al., 2004 ; Kahl & Voorhis, 2005). However, there are also some researches showed that heat has close relationship to task performance. The way to measure or assess the effect of temperature on task performance remains to be a major challenge to the ergonomists. Until now, there are no standard procedure to measure the workers' task performance.

Thermal discomfort is not only an unpleasant sensation, it might affect or translated to physiological and psychological response such as behavior or cognitive issues. It may also have adverse health effect if it is in extreme condition. According to Auliciems, Szokolay (2007), moderate thermal stress may improve human performance, however, thermal discomfort may leads to loss of capacities for physical and mental work.

Besides that, Nishihara et al., (2007) had conducted a long term field study for seven months to investigate the effect of thermal environment on human productivity. Seven male software programmer were participated in the study and required to answer questionnaires based on thermal sensation, fatigue and self-estimated productivity everyday. A software, Advanced Trail Marking Test (ATMT) was used as the estimation of performance. The results showed that the decrement in the total number of keystrokes of one day was 7.8% and that in the numbers of reaction per second of ATMT was 2.6% as temperatures dropped by 1.0°C below thermally neutral temperature. In general, overcooling brought the decrement of performance in the office.

Based on Buchberger (2008), speed based tests can be performed to evaluate the productivity and task performance on the human subject. The performance was measured in term of the speed. The speed based tests are bound to time availability. The output of the study is the number of right answers the subject gave per unit of time. The common speed based tests used to evaluate the task performance are Mathematics equation, Sudoku test and typing test.

According to Balazova, Clausen, Rindel, Poulsen, & Wyon (2008), they involved 15 subjects and experimented in simulated office. The temperatures are set on 23ºC and 28ºC. Task such as processing words are used as performance test. The result showed that there was a highly significant effect of both office type and temperature on the subjects' ability to concentrate and work performance.

Buchberger (2008) had also conducted a study between heat and task performance in office building. Eighteen respondents are exposed to three different temperatures (24°C, 28°C, 30°C) and performed Maths test, Sudoku test and typing test. The results showed that there is improvement in subjects' productivity between three different thermal environments across all the tests.

However, some reseaches showed opposite results from the other studies. According to Zhang et al. (2010), they had experimented the respondents with three different tasks which are Maths equation, Sudoku and typing test. The duration given for Sudoku, Maths test and typing test are 15 minutes, 8 minutes and 10 minutes respectively. The number of right answers the subject gave per unit of time is the parameter to measure performance rate. The result showed that the differences in typing rate among all the conditions are insignificant. Typing does not appear to be a sensitive method for evaluating performance in this range of environmental conditions. Buchberger (2008) also agreed that typing test is not significant in measuring the task performance.

Same goes to O'Neal & Bishop (2010), he conducted an experiment on 10 respondents who age between 23 to 29 years old and body-fat percentage within range of 6.9% to 18.1%. These 10 respondents were exposed to 30°C and 38°C and performed short-term memory test (MEM), simple arithmetic test (MATH) and computerized reaction time/tracking test (RTT). Short- term memory test requires respondents to memorize as much as they possible within 90 seconds. After the completion of 90 seconds, respondents are required to write it out as much as possible within 60 seconds. For the simple arithmetic test, it consists column of addition, subtraction and multiplication problems. The last test was the computerized test which clicking the dot in 6 X 10 grid circles within 30 seconds. The following link will lead to the test. (http://faculty.washington.edu/chudler/java/dottime.html). This study suggesting that the heat and physical activity did alter cognitive performance.

According to Melikov et al. (2013), he had conducted an experiment on 30 respondents. The participants are exposed to 23°C, 26°C and 28°C in climate chamber for 4 hours. Performance were assessed by simple Mathematic equations test. The finding showed that increasing the temperature and relative humidity significantly decreased tear film quality and the concentration of salivary alpha-amylase, indicating lower mental arousal and alertness. Thus, increasing temperature will lower task performance rate.

Cui et al. (2013) had experimented on 36 respondents with different thermal environment. The test they performed were memory typing. Memory typing is a long term memory task and require high mental demand and concentration. A software was used to aid the performance test. Six letters are randomly selected from the alphabet (the second and fourth letters were vowels) and presented on the screen for two seconds. The respondents are required to input them within five seconds. The results showed that learning effect was greatly affected by temperature. Under warm or cold discomfort environment or when the temperature was frequently changing, the learning and performance rate was slowed down.

As conclusion, there are many ways to measure the task performance rate but it is complicated. The differences between laboratory study and field study should be noted. In laboratory study, the tests are short term memory test and all thermal conditions are controlled and maintained. While in field study, we have to take in the variables to be controlled and design since the subjects and thermal conditions are changeable. Therefore, the link between laboratory study and real world is weak.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter is discussing about the research procedures that will be carried out throughout the study. This chapter consists of research design, study sample, study area, sampling techniques, process and procedures, data collection technique, research instruments, and data analysis.

3.2 STUDY LOCATION

The location for this study is located at a controlled room named Workplace Ergonomic Simulator at Block T, Universiti Malaysia Pahang (UMP). The room was equipped with an air-conditioner, which the temperature can be adjusted according to desired temperature settings.

Figure 3.1 Workplace Ergonomic Simulator

3.3 STUDY DESIGN

This study was a quasi-experimental study. The effects of three different temperature settings (20°C, 23°C and 26°C) on thermal comfort and task performance were determined by individual thermal comfort and preferences and typing speed respectively. The reason using quasi- experiment study is because of it is similar to true experiment. It is able to determine the casual relationship between the variables. . In other words, quasi- experiment is able to determine which treatment or program is able to lead to an expected outcome as same as true experiment. The only difference between true experiment and quasi- experiment is the element of random assignment to the treatment or control groups. Since in social science, pre- selection and randomization of groups are often difficult. By using quasi- experiment study, it can be done by "pre-post testing" which there are tests have been done before any data is collected to check if there are any confounding. The results are collected when the actual experiment is performed. It is useful for generating results for general trends.

In thermal comfort study, it is quite difficult to categorise the undergraduates into groups because human has their own thermal comfort preference and thus, it is unable to conduct experiment and determine the optimum temperature for highest task performance. By using quasi- experiment, we are able to do pre- selection to find suitable respondents according to the certain criteria.

3.4 SAMPLING

3.4.1 Sample Population

The study population for this study was the undergraduate students of Faculty of Engineering Technology, Universiti Malaysia Pahang. The aim of this study is to determine the optimum temperature for students to have higher or highest task performance in academic. Therefore, the respondents must be from undergraduates of Universiti Malaysia Pahang.

3.4.2 Sampling Sample

The study samples are included all undergraduate students from the programme of Occupational Safety and Health, Infrastructure Management, Electrical, Manufacturing, Pharmaceutical and Energy & Environment from Faculty Engineering Technology, UMP.

3.4.3 Sampling Frame

Name lists of the undergraduate students from different programmes were obtained from the Administration Department of Faculty of Engineering Technology, as the sampling frame for this study.

3.4.4 Sampling Unit

The sampling unit for this study is an undergraduate student of Faculty of Engineering Technology, Universiti Malaysia Pahang who fulfilled the inclusion criteria of this study.

3.4.4.1 Inclusion Criteria

1. Normal eyesight or have been corrected by eyeglasses or contact lenses
2. Normal BMI
3. Typing speed of more than 20 words per minute

3.4.4.2 Exclusion criteria

1. Females who having their menstrual cycle
2. Pregnant women

3.4.5 Sampling Method

Random sampling method was used to select subjects in this study. By this method, every undergraduates from Faculty of Engineering Technology has an equal chance to being selected as respondents. Besides that, it is easy and simple method to get respondents. Lastly, the results can be generalized for the whole population.

After the random sampling method, details of the study were explained to all undergraduate students that had fulfilled the criteria of this study. Students who were willing to participate in this study will be recruited as subjects.

3.5 STUDY INSTRUMENTS

3.5.1 Questionnaire

Questionnaire was used in this study is to obtain the required information for the research. The questionnaire was distributed to the respondents before the study started.

It consists of three parts, which the first part is about the socio-demographic factors of respondents. This part is required, as the study needs to determine the status of respondents including the age and health status of the respondents. While second part is the information of thermal exposure. In this section, duration of exposure to the cold or hot temperature are included. The last part covers the level of thermal comfort of respondents during the test. The ASHRAE Thermal Sensation Scale was used to evaluate the range of acceptance temperature.

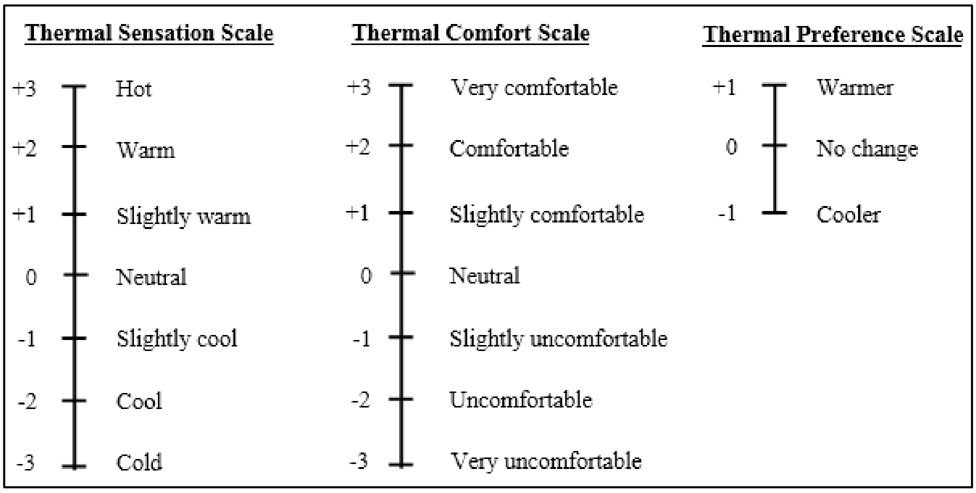

Figure 3.2: ASHRAE Thermal Sensation, Preference and Acceptability Scale

3.5.2 Wet Bulb Globe Temperature (WBGT)

WBGT was used to ensure the room temperature remains constant throughout the study process. Besides that, WBGT will be used to ensure the humidity and CO_2 level in the room are remain constant, so that it would not influence the temperatures and findings of this study.

Figure 3.3: Wet Bulb Globe Temperature (WBGT)

3.5.3 Ergonomic Chair and Table

The height of the chair and table are adjusted according to the Guidelines on Occupational Safety and Health for Seating at Work (2003). The arrangement of the workstation is also arranged according to the guideline as well.

Figure 3.4: Ergonomic Chair and Table

3.5.4 Weight and Height Measuring Scale

These 2 instruments were used to get the weight and height and used to calculate the BMI to ensure the criteria is fulfilled.

Figure 3.5: Weight and Height Measuring Scale

3.6 STUDY FRAMEWORK

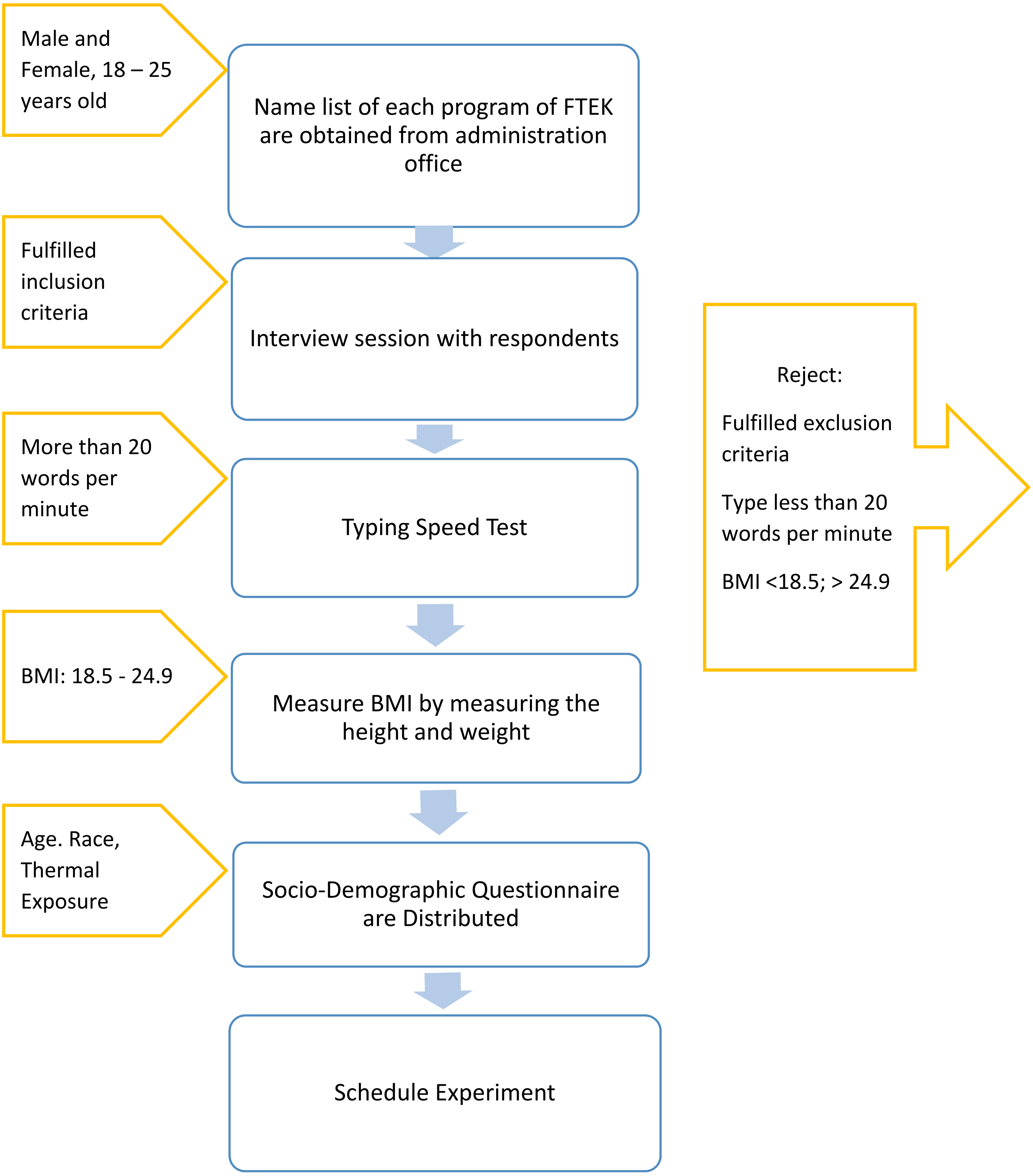

Figure 3.5: Procedure for respondent sampling

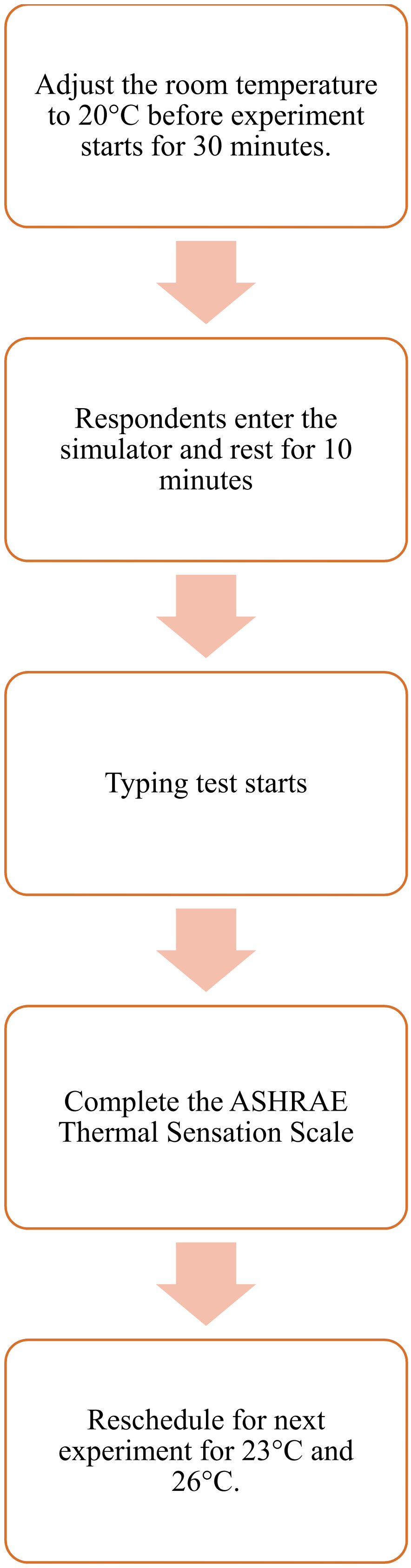

Figure 3.7 Procedure for the trial

3.7 DATA ANALYSIS

Data analysis is a process of transferring the information from sample and interpret it in a form of graph or any statistics way. In this study, data entry and analysis was analysed by using IBM SPSS Version 20.

3.7.1 Determination of Data Distribution

Normality test was used to determine the normality of the distributions of each variable studied before any statistical analysis can be carried out. By doing this, the type of analysis can be decided for the next chapter. In this study, Shapiro-Wilk Test was used to determine the normality of data distribution because the sample size (n=30) was below than 50. Table 3.1 shows that the data of scoring for typing task was normally distributed, as the $p > 0.05$.

Table 3.1: Determination of scoring for typing tasks data distribution by Shapiro-Wilk Test

Parameters	p-value (.sig)	Skewness	Kurtosis
Scoring at 20°C	0.377	0.528	-0.148
Scoring at 23°C	0.172	0.997	1.814
Scoring at 26°C	0.193	0.699	0.065

* Significant at $p > 0.05$

Normality test was also performed on the data of perception of thermal comfort. From the results on Table 3.2, it shows that the data distribution for all the variables in the thermal comfort at three different temperature settings were not normally distributed ($p< 0.05$).

Table 3.2: Determination of thermal comfort data distribution by Shapiro-Wilk Test

Parameters	p-value (.sig)	Skewness	Kurtosis
Thermal Comfort at 20°C	<0.001	0.841	-0.082
Thermal Comfort at 23°C	<0.001	0.170	-1.569
Thermal Comfort at 26°C	0.007	0.000	0.053

* Significant at $p > 0.05$

3.8 QUALITY CONTROL

3.8.1 Pre-test Questionnaire

A pre-test of the questionnaire was conducted among five undergraduate students of Faculty of Engineering Technology, Universiti Malaysia Pahang. The purpose of this pre-test conducted was to ensure that all respondents participated in the study can understand and answer the questions given. Comments were taken from each students and correction was made on the questionnaire. A final version of questionnaire was used after modifications have been made. Besides that, the reliability of the questionnaires had been tested with the Cronbach’s alpha analysis; with the values of 0.745.

3.8.2 Instrumentation

In order to ensure the validity and reliability of results, all Standard of Operation Procedures (SOP) of each instruments are followed and practiced during the study.

Besides that, the workplace are followed the guidelines that suggested by Department of Occupational Safety and Health. The sitting guideline was used to simulate the real workplace. All these standards and regulations are implemented to ensure the validity of the results.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter focuses on the data analysis of the collected data. Socio-demographic data will be described and discussed in this chapter. Besides that, thermal sensation and thermal comfort will be analyzed compared by Friedman Test. Comparison of the task performance under three different temperatures will be analyzed by ANOVA test. Relationships between temperature and task performance will also be analyzed using correlation test and then further discussed in this chapter.

4.2 DESCRIPTIVE DATA

4.2.1 Response Rate and Socio-demographic Data

A total of 30 respondents were recruited and participated in this study. According to Sekaran (2003), 30 respondents are enough to conduct an experimental based research. The recruitment of respondents was based on the inclusive and exclusive criteria of this study which is able to type 20 and more words. Majority of the respondents participated in this study are female which comprising approximately 56.7% (n=17) while the rest are male 43.3% (n= 13). In this study, proportion of the ethnicity Malay and non-Malay is 36.7% and 63.3% respectively.

The study showed that the average age of the respondents is 22.30 ± 1.055 years while the average BMI of the respondents is 20.910 ± 2.5792. Table 4.1 showed the demographic data of the respondents of this study.

Table 4.1: Demographic data of the respondents (N=30)

Variable	Undergraduate students, N=30		
	Frequency	Percentage (%)	Mean ± SD
Age			
19 – 21	7	23.3	
22 – 24	22	73.3	22.30 ± 1.055
≥ 24	1	3.3	
BMI			
≤ 18.4 (Underweight)	6	20.0	
18.5 – 24.9 (Normal)	20	66.7	20.910 ± 2.5792
≥ 25 (Overweight)	4	13.3	
Gender			
Male	13	43.3	-
Female	17	56.7	
Ethnicity			
Malay	11	36.7	
Chinese	13	43.3	-
Indian	6	20.0	
Others	0	0	
Programme of Study under Faculty of Engineering Technology			
Occupational Safety and Health	5	16.7	
Infrastructure Management	5	16.7	
Pharmaceutical	5	16.7	-
Energy & Environment	5	16.7	
Manufacturing	5	16.7	
Electrical	5	16.7	

4.2.2 Type of Ventilation Devices Used and Respondents' Thermal Sensation

Figure 4.1 shows the information on the environment that respondents most exposed to during their daily activity. According to Bob (2016), the global climate has changed rapidly and it is significant. Due to hot environment, people tended to spend most of their times in indoor environment. Based on the Figure 4.1, 80% of the respondents were exposed to the indoor environment and the rest (20%) were exposed to outdoor environment.

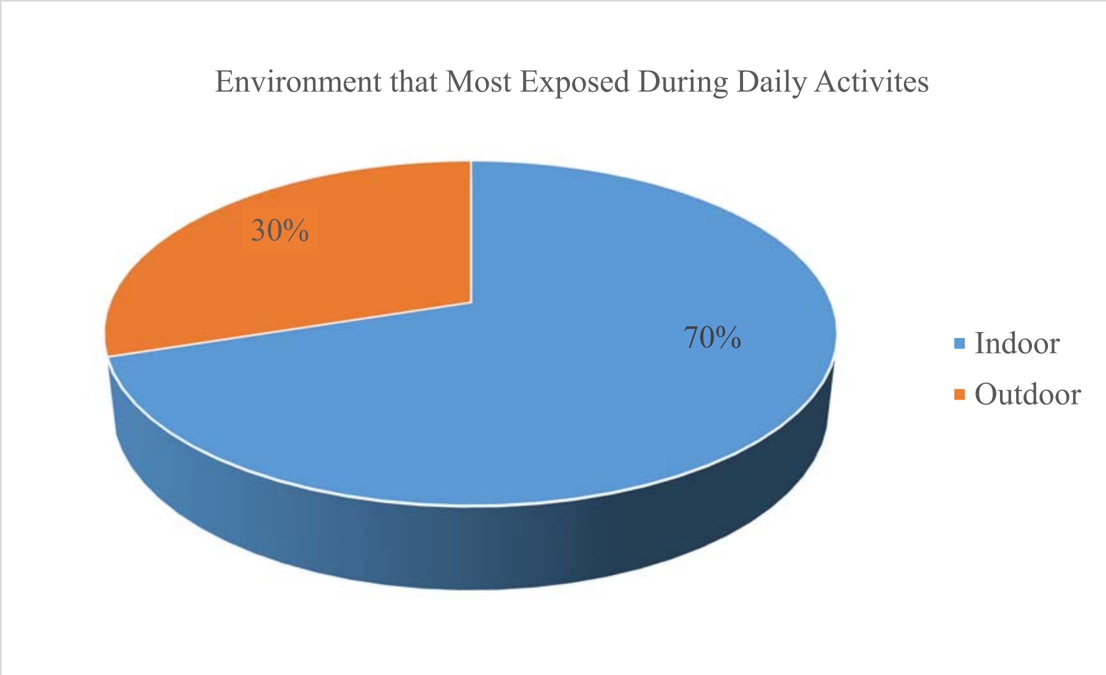

Figure 4.1: Environment that most exposed during daily activities

Figure 4.2 shows the type of ventilation device used on the environment exposed. Type of ventilation devices can be categorized into natural environment for outdoor environment, while, fan and air conditioner for indoor environment. The respondents that chose indoor environment used different type of ventilation. Based on the figure, 76.19% (n=16) out of 21 respondents who chose indoor environment, used fan as their ventilation device on that particular environment. 23.81% of respondents used air conditioner as their ventilation device in indoor environment.

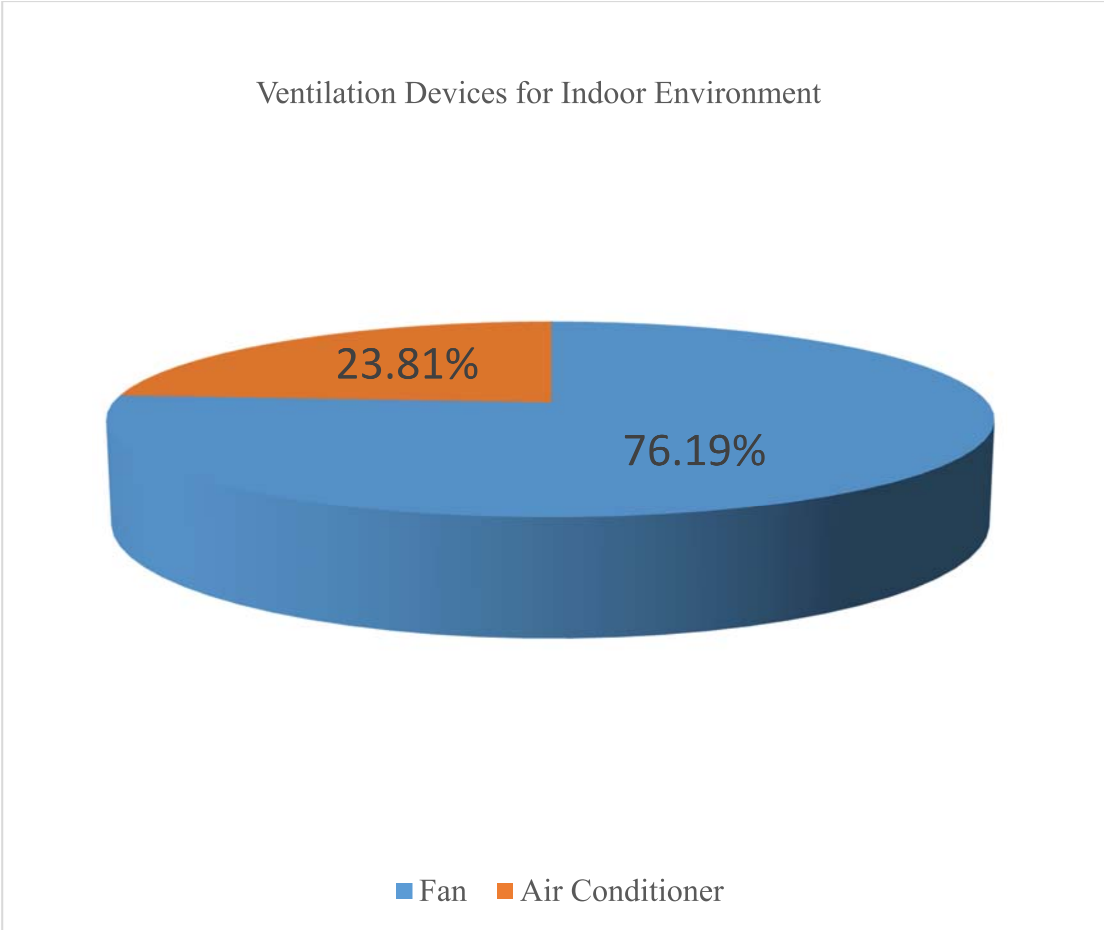

Figure 4.2: Type of ventilation device used on the environment exposed

Figure 4.3, 4.4 and 4.5 shows the thermal sensation of respondents for that particular ventilation devices. Based on Figure 4.3, 44.44% of respondents felt slightly warm and 33.33% of respondents felt hot when natural wind as their ventilation device.

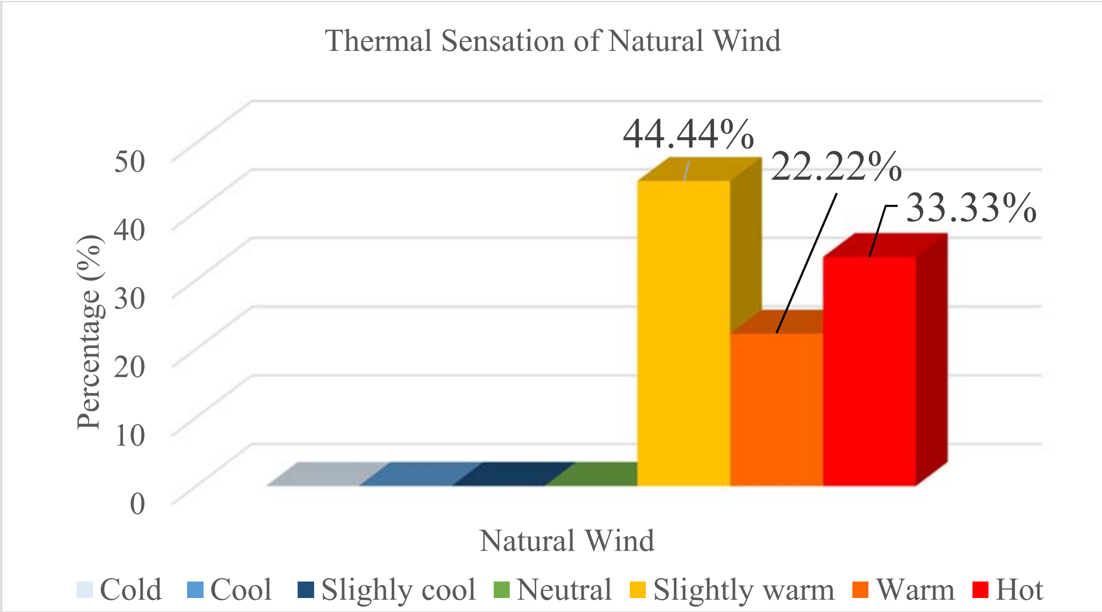

Figure 4.3: Thermal sensation on indoor environment (natural wind)

Based on the Figure 4.4, from 16 respondents, 50% of respondents felt slightly warm under the fan. 18.75% of respondents felt neutral and hot respectively.

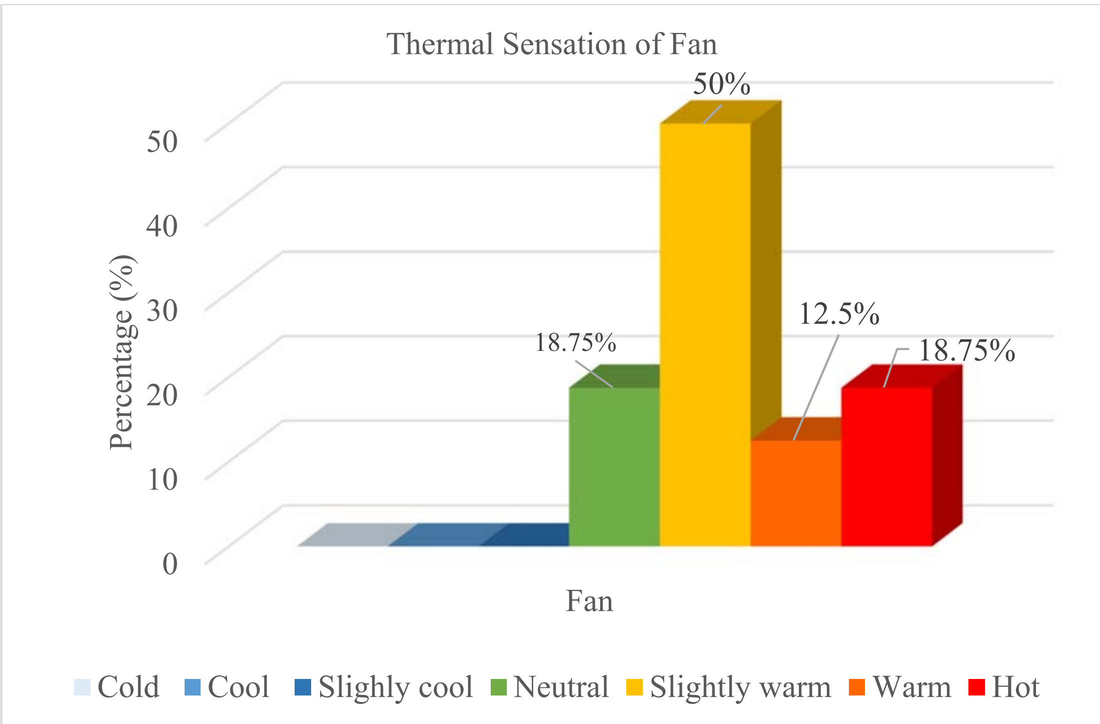

Figure 4.4: Thermal sensation on outdoor environment (fan)

Based on the Figure 4.5, out of five respondents who chose air conditioner as their ventilation device, 60% of respondents felt slightly cool and 40% of respondents felt neutral.

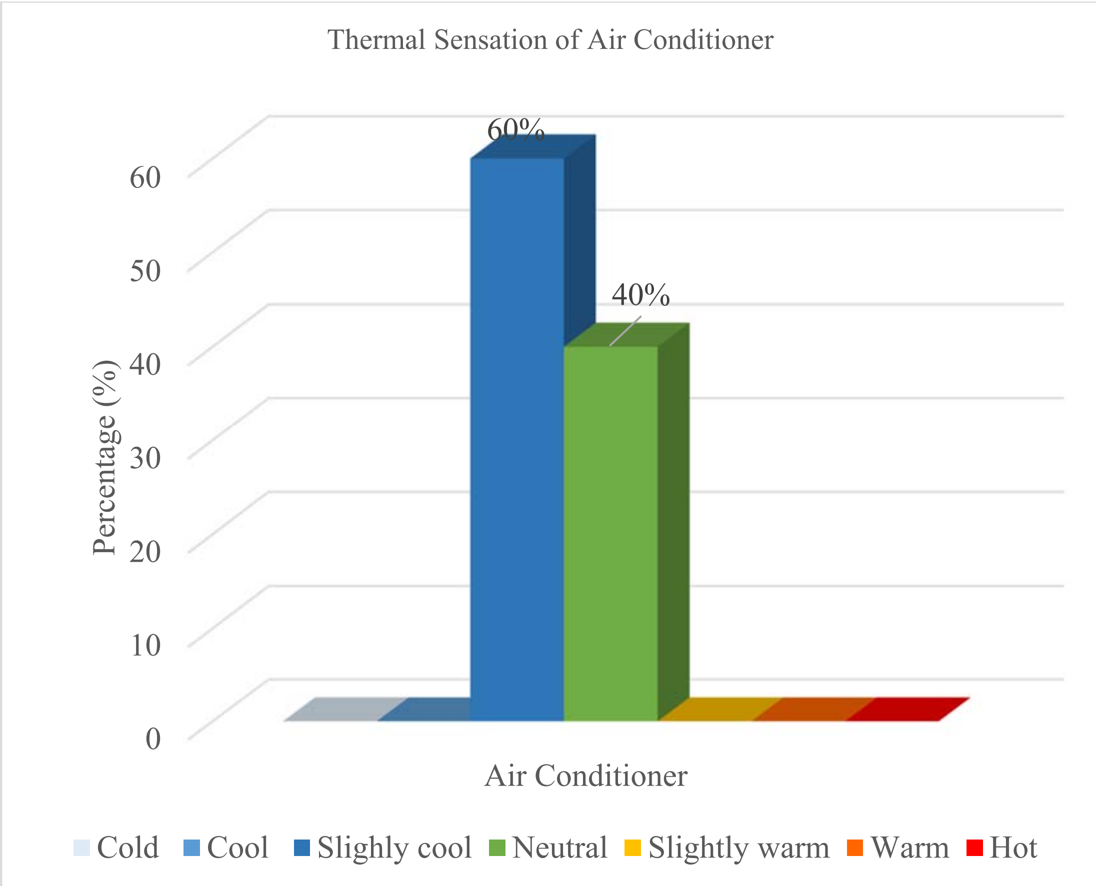

Figure 4.5: Thermal sensation on outdoor environment (air conditioner)

4.3 COMPARISON OF THERMAL COMFORT UNDER DIFFERENT TEMPERATURE SETTINGS

The first objective of this study is to compare the thermal comfort among undergraduate students of FTek under different temperature settings. The results of subjective responses to temperature were showed in the Figure 4.6, 4.7, 4.8 and 4.9.

Based on Figure 4.6, most of the respondents felt slightly cool at 20°C (43.33%) while another 8 person (26.67%) felt cool. The rest of 23.33% and 6.67% were felt neutral and slightly warm respectively. On the other hands, at 23°C, 19 respondents (63.33%) felt neutral and 8 respondents (26.67%) felt slightly cool. The remaining 5.57 % and 3.33% were felt slightly warm and warm respectively. As for the temperature at 26°C, most of the respondents voted warm, slightly warm and neutral with the percentage of 43.33%, 26.67% and 16.67% respectively. This showed that they adapted very well with the temperature of 23°C.

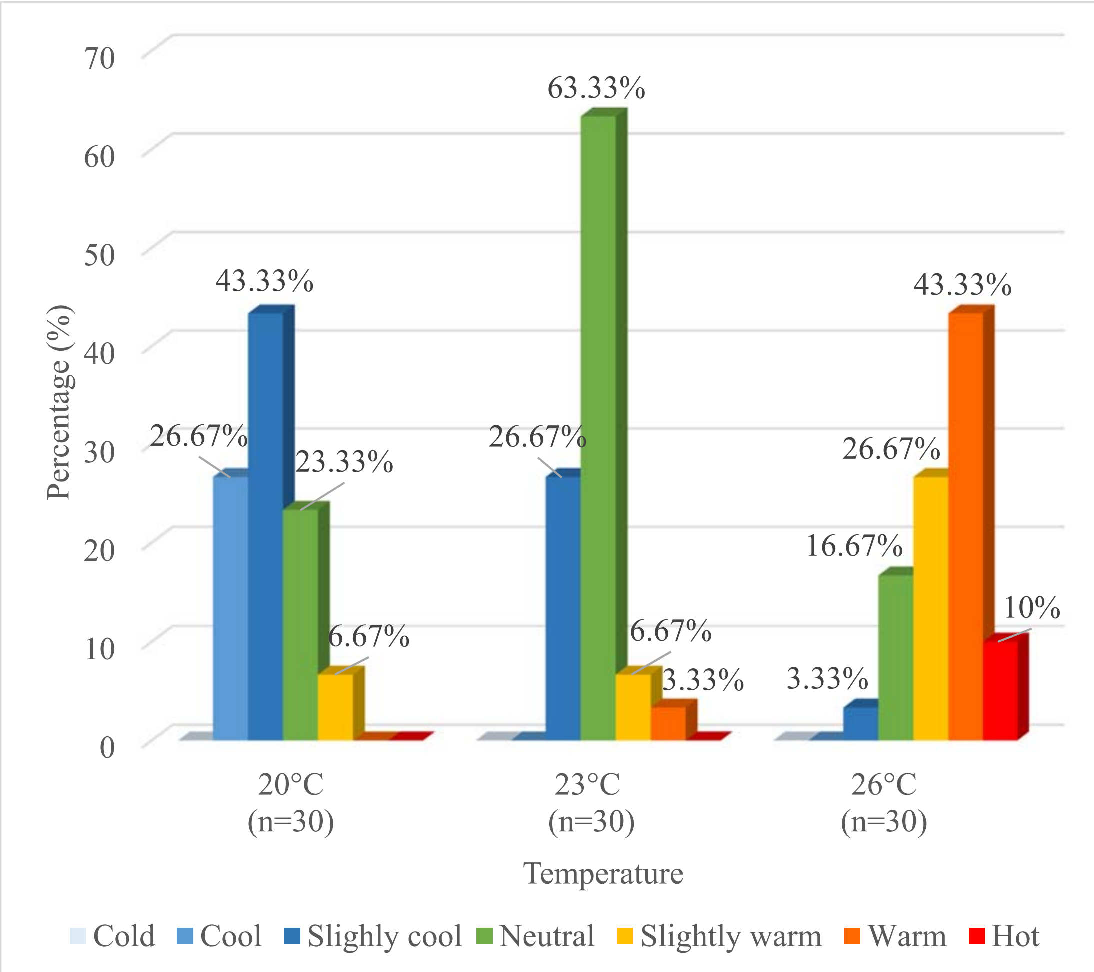

Figure 4.6: Subjective responses on thermal sensation at different temperature settings

Based on Figure 4.7, 46.67% of total respondents felt slightly uncomfortable and 23.33% felt neutral with the temperature of 20°C. On the other hands, at 23°C, 36.67% of respondents felt neutral and 23.33% of respondents felt comfortable. As for the temperature at 26°C, 46.67% of the respondents voted slightly uncomfortable. The voting of uncomfortable and neutral with the percentage of 23.33% and 23.33% respectively.

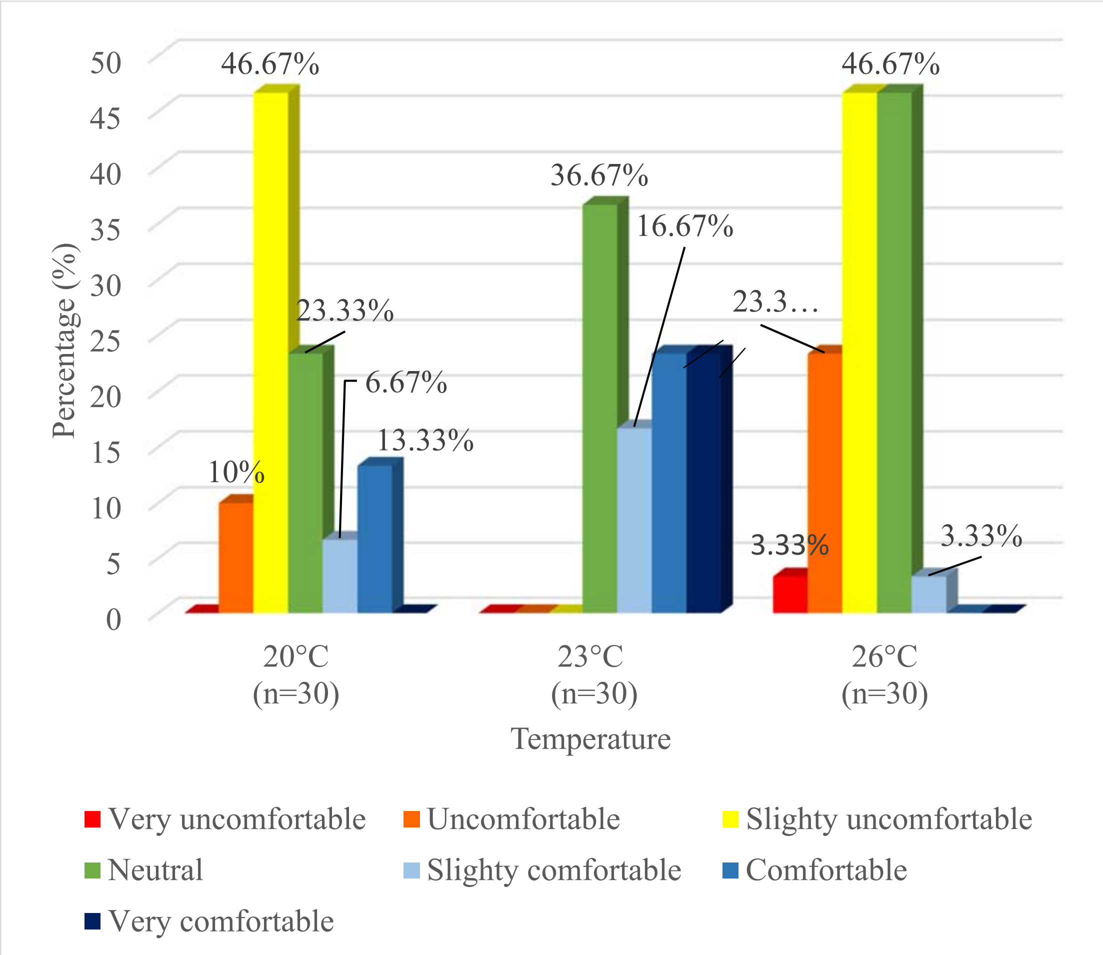

Figure 4.7: Subjective responses on general thermal comfort at different temperature settings

Figure 4.8 shows subjective responses on general thermal preference at different temperatures. At 20°C, approximately 76.70% of respondents (n=23) prefer the temperature to be warmer. On the other hands, at temperature of 23°C, 73.33% of the respondents (n=22) prefer the temperature to be maintained while for the temperature of 26°C, 80% of the respondents prefer the temperature to be cooler.

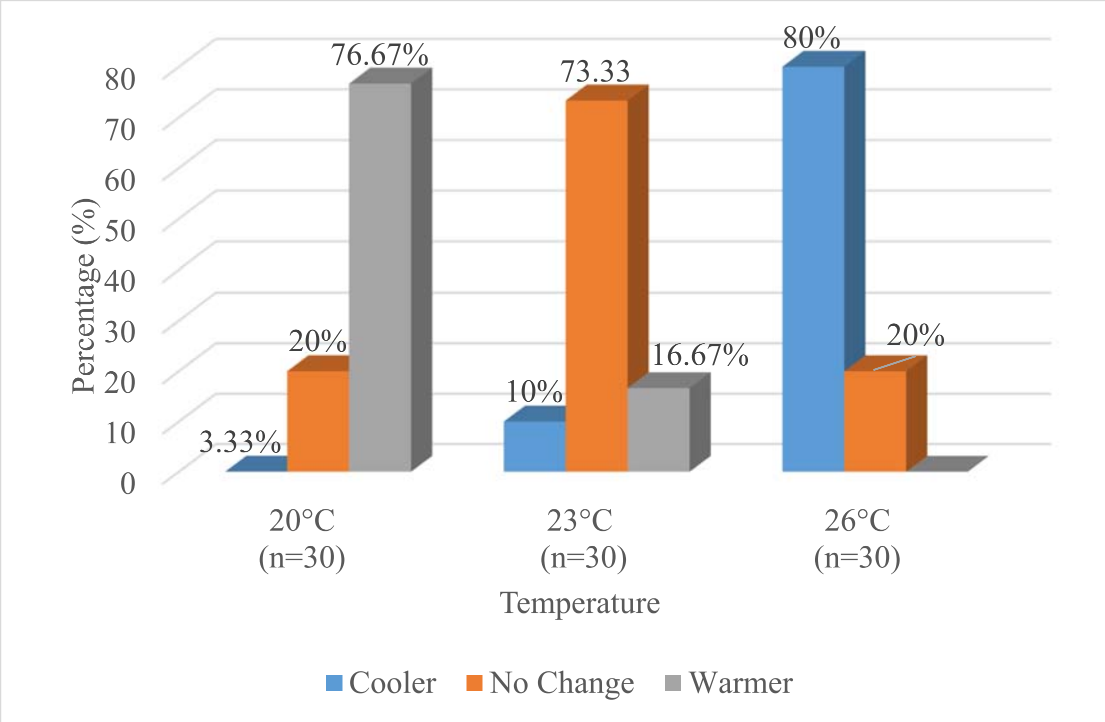

Figure 4.8: Subjective responses on general thermal preference at different temperature settings.

Thermal preference was expressed as temperature of an organism chooses from a range of potential temperature. Based on Figure 4.9 below, temperature of 23° is the most acceptable, with the total voting of 30 (100%). On the other hands, temperature of 20°C and 26°C were acceptable with the percentage of 66.67% and 40% respectively. In conclusion, respondent preferred cooler temperature at warm environment. This result was similar to the study by Fang, Wyon, Clausen and Fanger (2004). They found out that higher indoor air temperature and humidity was found more unacceptable.

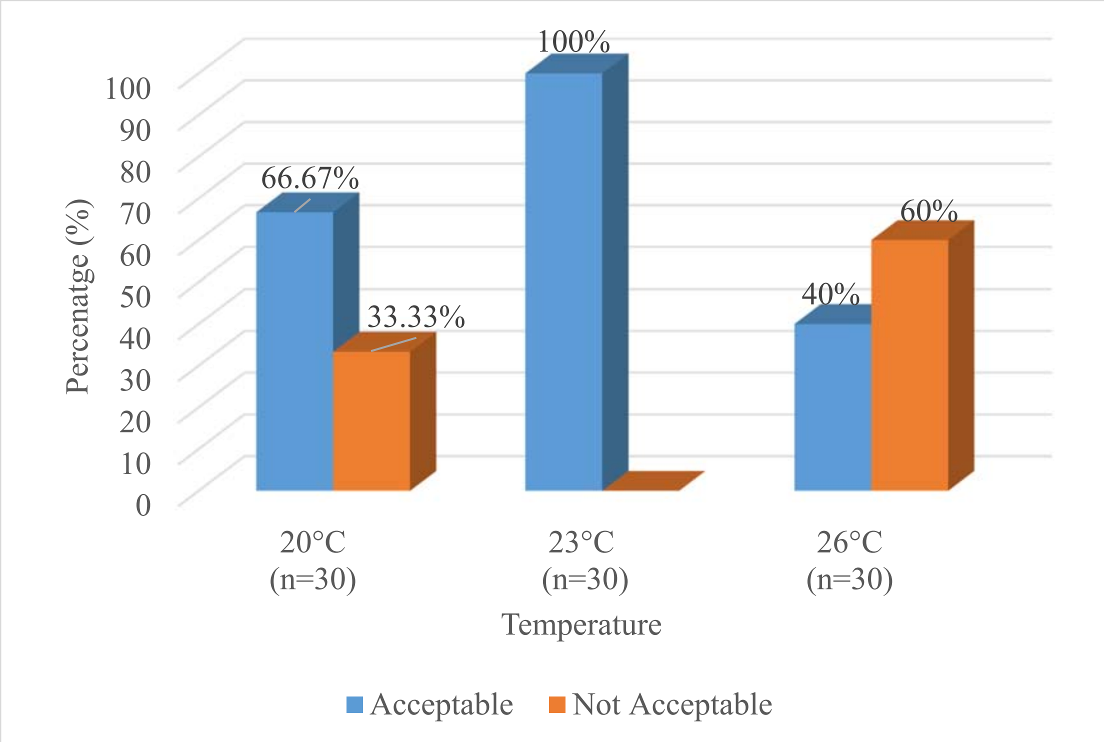

Figure 4.9: Subjective responses on thermal acceptability at different temperature settings.

As we discussed in the Chapter 3.7.1, the data distribution for subjective response of temperature is not normal. In order to test the differences between conditions among the same sample, the Friedman Statistical Test was used. Friedman Test is an alternative to the repeated- measures (ANOVA) when the data is not normal distributed (Field, 2013). For the Friedman test, the dependent variable must be measured on at least an ordinal scale. Table 4.2 shows the result of the Friedman Test. Based on the table, the subjective responses on thermal sensation of respondents showed significant different under 3 different temperature settings, $\chi^2(2) = 41.618$, $p < 0.001$. Besides that, the subjective responses on thermal comfort did significantly change over the 3 different temperature settings, $\chi^2(2) = 34.311$, $p < 0.001$. The subjective response on thermal preference and thermal acceptability among respondents showed significant change under 3 different temperature settings with $\chi^2(2) = 45.412$, $p < 0.001$ and $\chi^2(2) = 22.182$, $p < 0.001$ respectively. In conclusion, all the variables did show significant different ($p < 0.05$).

Table 4.2: Comparison of thermal comfort of respondents under three different temperature settings

Variables	Temperature	Mean Rank	Chi-square	p value
Thermal Sensation	20°C	1.33	41.618	p<0.0001*
	23°C	1.78		
	26°C	2.88		
General Thermal Comfort	20°C	1.78	34.311	p<0.0001*
	23°C	2.78		
	26°C	1.43		
Thermal Preference	20°C	2.77	45.412	p<0.0001*
	23°C	2.07		
	26°C	1.17		
Thermal Acceptability	20°C	2.03	22.182	p<0.0001*
	23°C	1.53		
	26°C	2.43		

*significant at $p \leq 0.05$

As all variables showed significant difference, therefore, post-hoc test (Wilcoxon Signed Rank Test) was used. By using Wilcoxon Signed Rank Test, the comparison within the variables can be calculated. Table 4.3 below shows the post-hoc test analysis result. Based on the result of the post-hoc test, the comparison within the variables showed significant different ($p < 0.05$).

Table 4.3: Pairwise comparison (Wilcoxon Signed Rank Test) of the effects of temperature on thermal comfort under three different temperature settings.

Variables	Temperature	Temperature	Z value	p value
Thermal Sensation	20°C	23°C	-3.155	0.002*
	20°C	26°C	-4.596	p<0.001*
	23°C	26°C	-4.750	p<0.001*
General Thermal Comfort	20°C	23°C	-4.002	p<0.001*
	20°C	26°C	-2.066	0.039*
	23°C	26°C	-4.472	p<0.001*
Thermal Preference	20°C	23°C	-3.489	p<0.001*
	20°C	26°C	-4.756	p<0.001*
	23°C	26°C	-4.564	p<0.001*
Thermal Acceptability	20°C	23°C	-3.162	0.002*
	20°C	26°C	-2.000	0.046*
	23°C	26°C	-4.243	p<0.001*

N=30
*significant at p≤0.05

4.4 COMPARISON OF TYPING-BASED TASK PERFORMANCE UNDER THREE DIFFERENT TEMPERATURE SETTINGS

The second objective is to compare task performance of undergraduate students of FTek under three different temperature settings. Figure 4.10 shows that the mean score for the typing-based task performance of the respondents at three different temperature settings.

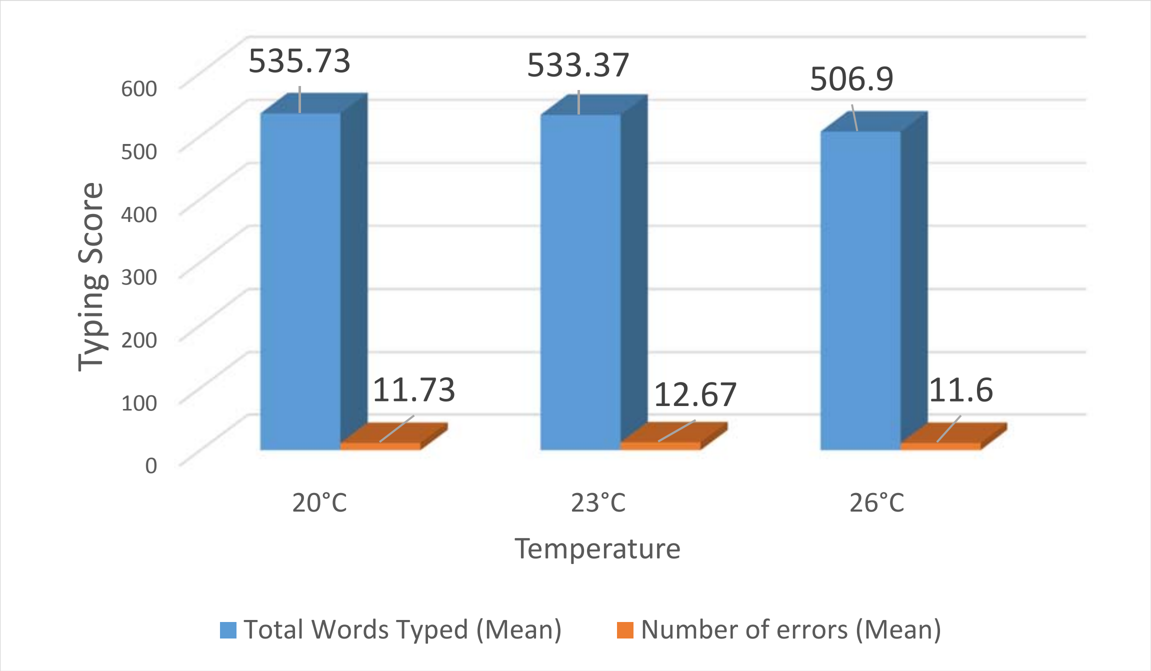

Figure 4.10: Comparison of Scoring of the Typing-based Task Performance Within 20 minutes under Three Different Temperature Settings

Repeated measured ANOVA was conducted to compare the task performance of respondents under different temperature settings. In order to continue the repeated measured ANOVA analysis, the assumption of sphericity which is the equality of variances of the differences between treatment levels must be met. Mauchly's Test of Sphericity was used to ensure the assumption of sphericity for the task performance had not been violated. If the Mauchly's Test statistic is not significant ($p>0.05$), then it is reasonable to conclude that the variances of differences are equal. Table 4.4 is the result of the Mauchly's Test of Sphericity. Based on the table, Mauchly's test indicated that the assumption of sphericity has not been violated, $\chi^2(2) = 0.292$, $p = 0.864$. In other words, the variance of the population is equal.

Table 4.4: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
Performance (20°C, 23°C, 26°C)	0.990	0.292	2	0.864

*significant at p<0.05

Table 4.5 shows the comparison of task performance (total words typed) of respondents under 3 different temperature settings. Based on the result, the mean of typing speed was similar on the temperature of 20°C and 23°C.However, as the temperature was increased to 28°C, the typing speed was decreasing. This result similar to the research done by Zhang et al. (2004), the task performance was frequently better in a cold temperature compared to neutral condition. Besides that, Aluciems (1972) discovered that lower temperatures were associated with better task performance in his study. This may due to physiological arousals that arise from the fluctuations of temperature. From the table, the task performance was showed significant different under 3 different temperature settings, p<0.001. In other words, task performance showed differences under 3 different temperature settings.

Table 4.5: Comparison of task performance (total words typed) of respondents under 3 different temperature settings

Temperature	Mean ± SD	F (df)	p value
20°C	535.73 ± 131.920		
23°C	532.43 ± 125.255	8.310 (2)	**0.001**
26°C	506.90 ± 114.697		

*significant at p≤0.05

As the result in Table 4.6, there was significant difference of task performance across 3 different temperatures. Therefore, the post hoc analysis was performed. Post hoc analysis was normally performed after the comparison between the variables. This is because post hoc analysis will show which pair of variables have the difference. Post hoc analysis (Pairwise Comparison test) is designed to compare all different combinations of the treatment groups by comparing the means of all combinations of pairs of variable. If the $p < 0.05$, it shows significant between the pair and concluded that it was significantly changes between the paired variables. Table 4.6 shows the pairwise comparison of task performance under 3 different temperature settings. Based on the result, it shows that typing-based task performance of respondents working at the temperature of 20°C was statistically different from the task performance at 26°C ($p=0.004$). The mean difference between these two variables was 28.833. Besides that, the task performance at the temperature of 23°C also showed statistically different from the task performance at 26°C ($p=0.006$), with the mean difference of 25.533. However, typing-based task performance at 20°C did not showed any significant different with typing based performance at 23°C ($p=1.000$).

Table 4.6: Pairwise comparison of task performance under three different temperature settings

Variable	Temperature	Temperature	Mean Difference	p value
	20°C	23°C	3.300	1.000
Task Performance	20°C	26°C	28.833	0.004*
	23°C	26°C	25.533	0.006*

N = 30

*significant at $p \leq 0.05$

4.5 CORRELATION BETWEEN THERMAL COMFORT AND TASK PERFORMANCE UNDER THREE DIFFERENT TEMPERATURE SETTINGS

The third objective is to determine the relationship between thermal comfort and task performance under three different temperature settings. Spearman Rank Correlation Coefficient was being used to determine the relationship between these two variables. All the results for three different temperature settings did not showed any significant relationship between thermal comfort and typing-based task performance ($p > 0.05$).

Table 4.7: Correlation between respondents' thermal comfort and typing-based task performance under different temperatures.

Respondents' Thermal Comfort at	Number of Correct Words (Mean) Correlation Coefficient	p value
20°C	-0.052	0.784
23°C	-0.073	0.701
26°C	-0.290	0.120

N=30
*significant at p≤0.01

4.6 CORRELATION BETWEEN AGE, GENDERS, ETHNICITY AND BMI WITH THE TASKPERFORMANCE UNDER THREE DIFFERENT TEMPERATURE SETTINGS

The forth objective of this study was to determine the relationship between age, genders, ethnicity, BMI and programme of study with typing-based task performance under three different temperature settings. Based on the correlation test conducted, all socio-demographic factors, such as age, genders, BMI and programmes of study did not correlate with the typing-based task performance ($p>0.05$).

Table 4.8 provided the information necessary to predict the relationship between the task performance from the age, genders, ethnicity, BMI value and programmes of study.

Table 4.8: Correlation between task performances with socio-demographic status across 3 different temperature settings.

Variables	Task performance at 20°C		Task performance at 23°C		Task performance at 26°C	
	Correlation Coefficient	p value	Correlation Coefficient	p value	Correlation Coefficient	p value
Genders	-0.198	0.294	-0.159	0.400	-0.210	0.266
Age	-0.068	0.720	-0.014	0.941	0.054	0.776
Ethnicity	0.76	0.689	0.269	0.151	0.176	0.354
BMI	0.025	0.897	0.100	0.597	0.008	0.965

N=30

*significant at $p \leq 0.01$

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, the findings of the research are concluded based on the data obtained and analyzed throughout the research. The conclusions were made based on the statistical analysis supported by past researches. The recommendations suggested in this chapter will be useful for the thermal comfort and task performance.

5.2 CONCLUSION

Indoor temperature is one of the fundamental characteristics to determine the comfort of occupant in indoor environment. Indoor air temperature may negatively affect human performance rate and human physical response if it is not properly controlled. To design a safe and comfort a place of work, human thermal comfort need to be determined. Human thermal comfort is defined as psychological state of expressing satisfaction towards surrounding thermal environment. Human thermal comfort condition is achieved where at least 80% of the occupants are satisfied with the indoor temperature. It is also believed that, with ample satisfaction towards surrounding, human can achieve optimum level of performing task.

The global climate has changed rapidly and it is significant. Due to hot environment, people tended to spend most of their times in indoor environment. As in the result, most of the respondents (80%) spend their time in indoor environment with air-conditioners or fans as their ventilation devices. 50% of the fan using respondents felt the temperature as slightly warm.

The rest 18.75%, 12.5% and 18.75% of fan using respondents felt neutral, warm and hot respectively. As for air conditioner as ventilation device, 60% of respondents felt slightly cool and 40% respondents felt neutral.

The first objective is to compare the thermal comfort under three different temperature settings. Based on the results, subjective responses on thermal sensation of slightly cool was highest at the temperature of 20°C (43.33%). This caused the respondents felt slightly uncomfortable and 20 out of 30 respondents requested to have a warmer temperature. Unlike at the temperature of 23°C, most of the respondents (63.33%) felt neutral and their subjective responses on thermal comfort were neutral, which they requested no change on the temperature settings.

Repeated measured ANOVA was used to compare the task performance of respondents under different temperature settings. The result showed significant difference between the task performances across 3 different temperature settings ($p=0.001$). Post hoc (Pairwise Comparison) test was performed and significant differences were only showed in comparing typing-based task performance between 20°C with 26°C ($p=0.006$) and between 23°C with 26°C ($p=0.004$). However, based on the results, there was no significant difference of task performance between 20°C and 23°C ($p>0.05$).

Based on the Spearman Rank Correlation Coefficient, it indicated that there were no significant relationship between thermal comfort and task performance ($p>0.05$). Although the tested temperatures affected the subjective responses on thermal comfort and thermal sensation, it had no impacts on the performance of typing-based task.

Correlation were used to determine the relationship between age, genders and ethnicity with task performance. Based on the results of the analysis, all of variables had no significant effects on the task performance at three different temperatures. All the variables showed the significant more than $p=0.05$.

5.3 STUDY LIMITATIONS

There are few limitations found in this study. One of them is Hawthorne effects. The feelings being observed and cared within the respondents may improve their performance in typing-based task. They might try to acted and performed differently than their normal speed, as they felt so special of being observed.

Besides that, data on the subjective responses of thermal sensation and thermal comfort were based on co-operation of the respondents. The responses given may not accurately describe their actual comfort and sensation at that current moment.

5.4 RECOMMENDATIONS

Based on the findings of this study, managements of faculty may consider using the recommended temperature settings, which is 23°C. This temperature settings (23°C) also recommended by the study of Ismail, Yusof, Makhtar, Deros and Rani (2010). By doing this, it may increase the thermal comfort of the occupants, which are students and staffs. Therefore, complaints by the building occupants on the indoor air temperature and air quality will decrease.

Besides that, students or perhaps working organizations may also use the findings of this study to adjust the temperature of their workstations in ensuring their thermal comfort maintained at comfort level. The adjustment of the workstation’s temperature must be according to the nature of work and other factors, such as clothing factor.

5.5 FUTURE RESEARCH

For further improvements on this study, it is recommended that this study should be further conducted with more tasks than this study. For example, mathematics tasks, word-recall tasks, memorizing task and cognitive skills may become one of the variables that can examined as task performance. Besides that, Santa Ana dexterity test may also be performed, as there were complaints from respondents saying that their hands dexterity was reduced.

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APPENDICES A

GANTT CHART FOR FINAL YEAR PROJECT 1 & 2

ACTIVITIES	SEMESTER 2 2015/2016					SEMESTER BREAK		SEMESTER 1 2016/2017			
	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Brainstorming											
Preparing Research Proposal (FYP 1)											
Submission of Research Proposal											
Presentation											
Data Collection											
Data Analysis											
Preparation of Thesis (FYP 2)											
Submission of Thesis											
Final Presentation											

APPENDICES B

QUESTIONNAIRE

EFFECT OF TEMPERATURE ON TASK PERFORMANCE AND THERMAL COMFORT AMONG UNDERGRADUATES OF FACULTY OF ENGINEERING TECHNOLOGY, UNIVERSITI MALAYSIA PAHANG

Instruction: Please ANSWER ALL questions below. Thank you.

For the use of researcher

Part I: Personal Information

1. Gender : ☐ Male ☐ Female — **Q 1** ☐
2. Age : ____________________________ — **Q 2** ☐
3. Race : ☐ Malay ☐ Chinese ☐ Indian ☐ Others (__________________) — **Q 3** ☐
4. Height : _____________ cm — **Q 4** ☐
5. Weight : _____________ kg — **Q 5** ☐
6. Programme :
   - ☐ Occupational Safety and Health (OSH)
   - ☐ Energy & Environment
   - ☐ Infrastructure Management
   - ☐ Manufacturing
   - ☐ Pharmaceutical
   - ☐ Electrical

   Q 6 ☐
7. Years of study :
   - ☐ 1 year
   - ☐ 3 years
   - ☐ 2 years
   - ☐ 4 years

   Q 7 ☐

Part II: Information on Thermal Exposure

8. Which environment are you exposed to most of the day?
   - ☐ Outdoor
   - ☐ Indoor

   Q 8 ☐
9. What type of device used in that environment for ventilation purposes?
   - ☐ Natural wind
   - ☐ Fan
   - ☐ Air-conditioner

   Q 9 ☐

10. How many hours you spend in that particular environment?

    ____________________ hours/day

Q 10

11. When you are in that particular environment, how do you feel?

    (Circle based on how you feel at the scale below)

-3	-2	-1	0	1	2	3
Cold	Cool	Slightly cool	Neutral	Slightly warm	Warm	Hot

Q 11

Part III: Perception of Thermal Comfort at First Trial

12. How do you feel at this temperature?

-3	-2	-1	0	1	2	3
Cold	Cool	Slightly cool	Neutral	Slightly warm	Warm	Hot

Q 12

13. How do you consider about this temperature setting at this moment?

-3	-2	-1	0	1	2	3
Very uncomfortable	Uncomfortable	Slightly uncomfortable	Neutral	Slightly comfortable	Comfortable	Very comfortable

Q 13

14. Right now, I would prefer to be

    ☐ Cooler

    ☐ No change

    ☐ Warmer

Q 14

15. On the basis of your personal preferences, how would you consider this temperature setting?

    ☐ Acceptable

    ☐ Not acceptable

Q 15

Part V: Perception of Thermal Comfort at Second Trial

16. How do you feel at this temperature?

-3	-2	-1	0	1	2	3
Cold	Cool	Slightly cool	Neutral	Slightly warm	Warm	Hot

Q 16 ☐

17. How do you consider about this temperature setting at this moment?

-3	-2	-1	0	1	2	3
Very uncomfortable	Uncomfortable	Slightly uncomfortable	Neutral	Slightly comfortable	Comfortable	Very comfortable

Q 17 ☐

18. Right now, I would prefer to be
    - ☐ Cooler
    - ☐ No change
    - ☐ Warmer

Q 18 ☐

19. On the basis of your personal preferences, how would you consider this temperature setting?
    - ☐ Acceptable
    - ☐ Not acceptable

Q 19 ☐

Part VI: Perception of Thermal Comfort at Third Trial

20. How do you feel at this temperature?

-3	-2	-1	0	1	2	3
Cold	Cool	Slightly cool	Neutral	Slightly warm	Warm	Hot

Q 20 ☐

21. How do you consider about this temperature setting at this moment?

-3	-2	-1	0	1	2	3
Very uncomfortable	Uncomfortable	Slightly uncomfortable	Neutral	Slightly comfortable	Comfortable	Very comfortable

Q 21 ☐

22. Right now, I would prefer to be
    - ☐ Cooler
    - ☐ No change
    - ☐ Warmer

Q 22 ☐

23. On the basis of your personal preferences, how would you consider this temperature setting?

    ☐ Acceptable

    ☐ Not acceptable

Q 23 ☐

END OF QUESTIONNAIRE… THANK YOU… ☺

APPENDICES C

RESPONDENT CONSENT FORM

RESEARCH TITLE : Effect of Temperature on Task Performance and Thermal Comfort Among Undergraduates of UMP

RESEARCHER : Tan Zhen Sheng

I ……………………………………………………………………………. Identity Card No. ……………………………address…………………………………………………………………………… ……………………………... ……………………………………………………..hereby voluntarily agree to take part in the clinical research specified above.

I have been informed about the nature of the clinical research in terms of methodology. I understand that I have the right to withdraw from this clinical research at any time without assigning any reason whatsoever. I also understand that this study is confidential and all information provided with regards to my identity will remain private and confidential.

Signature ……..……………………………

(*Respondent*)

Date :……………………………………..

I confirm that I have explained to the respondent the nature and purpose of the above –mentioned clinical research.

Date ……..…………………………… Signature ……..…………………………….

(Researcher)